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**U.S. Army  
Environmental  
Center**

**FORT DEVENS  
FINAL REMEDIAL  
INVESTIGATION  
FOR GROUP 2 & 7 SITES**

**FINAL  
REMEDIAL INVESTIGATION REPORT  
AREA OF CONTAMINATION (AOC) 43J**

**VOLUME I OF II**

**CONTRACT DAAA-91-D-0008  
DELIVERY ORDER NUMBER 005**

**U.S. ARMY ENVIRONMENTAL CENTER  
ABERDEEN PROVING GROUND, MARYLAND**

**February 1996**

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**FINAL  
REMEDIAL INVESTIGATION REPORT  
AREA OF CONTAMINATION (AOC) 43J**

**VOLUME I OF II**

**CONTRACT DAAA15-91-D-0008  
DELIVERY ORDER NUMBER 005**

*Prepared for:*

**U.S. Army Environmental Center  
Aberdeen Proving Ground, Maryland**

*Prepared by:*

**ABB Environmental Services, Inc.  
Portland, ME  
Project No. 07053-15**

**February 1996**

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## PREFACE

In 1991, the U.S. Department of the Army and U.S. Environmental Protection Agency signed a Federal Facility Agreement under Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act for environmental investigations and remedial actions at Fort Devens, Massachusetts. The agreement required that Site Investigations be undertaken at each Study Area to verify whether a release or potential release exists, to determine the nature of the associated risk to human health and the environment, and to determine whether further investigations or response actions may be required.

In 1991, Fort Devens was identified for closure, by July 1997, under Public Law 101-510, the Defense Base Closure and Realignment Act of 1990. This has resulted in accelerated schedules for the environmental investigations at Fort Devens.

In 1991, under contract DAAA15-91-D-0008, the U.S. Army Environmental Center (formerly U.S. Toxic and Hazardous Materials Agency) tasked ABB Environmental Services, Inc. to conduct Site Investigations at 13 Study Areas in Groups 2 and 7 and the Historic Gas Stations (19 sites), as described in the Fort Devens Master Environmental Plan (Biang et al., 1992). The findings of these site investigations are presented in the Final Site Investigation Report (ABB-ES, 1993a). Based on the results of the site investigations at these Study Areas, the Army decided to conduct supplemental site investigations at 14 of the original 32 Study Areas. The findings of these supplemental site investigations are presented in the Supplemental Site Investigation Data Package Groups 2 and 7 (ABB-ES, 1994a). Upon completion of the Supplemental Data Package it was recommended that three Study Areas (Study Area 41, 43G and 43J) should progress to the Remedial Investigations and Feasibility Study phase. The name designation for each of these Study Areas were administratively changed to Areas of Contamination and will be addressed as such in this Remedial Investigation Report and associated Feasibility Report. This Report presents the findings from Area of Contamination 43J (formerly Study Area 43J).

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## **EXECUTIVE SUMMARY**

ABB Environmental Services, Inc. (ABB-ES) has prepared this Remedial Investigation (RI) Report on Area of Contamination (AOC) 43J, the former waste oil and historic gas station gasoline underground storage tank (UST) in the 10th Special Forces motor pool, at the Fort Devens U.S. Army Installation, Massachusetts (Fort Devens) to support Task Order 005 of Contract DAAA15-91-D-0008 with the U.S. Army Environmental Center (USAEC). This RI Report details the results of the RI and previous investigations completed at the AOC 43J, which were completed in accordance with relevant U.S. Environmental Protection Agency (USEPA) and USAEC guidance. Fort Devens is currently on the National Priorities List (NPL) and AOC 43J is considered a subsite to the entire installation.

The RI field investigation was conducted at AOC 43J during September and October 1994 and included a seismic survey, subsurface soil sampling for field analysis at 47 locations using ABB-ES' TerraProbe™ system, installation of six water table groundwater monitoring wells, completing 15 soil borings with subsurface soil sampling for field and off-site laboratory analysis, and two rounds of groundwater sampling from six new and seven existing monitoring wells. The scope of work for this RI at AOC 43J was specified by the USAEC based on previous studies and investigations, and USEPA and Massachusetts Department of Environmental Protection (MADEP) comments on previous investigations and reports. USAEC directed this RI at Fort Devens to evaluate the nature and distribution of the contamination in soil and groundwater downgradient and crossgradient of the former waste oil and historic gas station UST. In general, the efforts associated with this RI have generated a conceptual model that identifies the source of the detected soil and groundwater contamination to be waste oil and gasoline floating on the water table and in the soil at and directly east (downgradient) of, the former UST locations. Evaluation of the RI results also indicated that the highest concentrations of site-related groundwater contamination in the source area are above the standards/guidelines established for the commercial/industrial risk scenario used to determine human health risks.

The analytical data indicated that the groundwater contamination appears to be located in the soils and the upper portion of the bedrock below and directly

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downgradient of the former UST locations. The water table below the UST locations is found in the overburden soils, but seasonally fluctuates down below the bedrock surface. The groundwater table leaves the bedrock just downgradient of the former UST locations and remains in the overburden soils across the remainder of the AOC. This groundwater fluctuation and media variation, has caused fuel-related contaminants to migrate into bedrock fractures and overburden soils downgradient and crossgradient of the AOC. The distribution of benzene (the site-related contaminant with the lowest federal drinking water Maximum Concentration Limit [MCL]) has been determined based upon the results of field and off-site groundwater sampling results (see Figure 7-1 and 7-2). Based upon these measurements, contamination is migrating south and east from the former UST locations in the same direction as the apparent groundwater flow.

Since groundwater contaminant concentrations exceed drinking water criteria, a key issue is the future use of groundwater at and around the AOC. AOC 43J is slated to remain within the proposed U.S. Army Reserve Enclave (BRAC, 1991). Potential health risks associated with exposure to subsurface soil at the source area and the perimeter area of AOC 43J were evaluated. The primary CPCs identified in soil were ethylbenzene, toluene, xylene, noncarcinogenic PAHs, and inorganic compounds. The exposure scenarios evaluated were for a utility/maintenance worker and a construction worker. Estimated carcinogenic risks did not exceed the USEPA risk range or MADEP MCP risk level. Similarly, potential noncarcinogenic risks did not exceed the USEPA and MADEP MCP target level.

Risks associated with exposure to unfiltered and filtered groundwater were evaluated for groundwater representing the source area and for groundwater identified as downgradient. The receptor evaluated was a future commercial/industrial worker. Estimated carcinogenic risks for unfiltered groundwater exceeded the USEPA target risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  for exposure to both mean and maximum concentrations of contaminants of potential concern (CPCs) in source area groundwater ( $3 \times 10^{-4}$  and  $6 \times 10^{-4}$ , respectively). Arsenic was the primary contributor to the excess risk (exceeding  $1 \times 10^{-4}$  risk level). Assuming exposure to maximum concentrations, benzene and carbon tetrachloride produced individual risks above  $1 \times 10^{-5}$ . In unfiltered downgradient groundwater, estimated carcinogenic risks were within the USEPA target risk range.

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Risks were estimated for commercial/industrial worker exposure to filtered groundwater assuming that concentrations of organic CPCs remain the same as in unfiltered groundwater. Estimated carcinogenic risks exceeded the USEPA risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  for exposure to both mean and maximum concentrations of CPCs in source area groundwater ( $2 \times 10^{-4}$  and  $5 \times 10^{-4}$ , respectively). Arsenic and benzene were the primary contributors to the excess risk for mean concentrations; while arsenic, benzene, and carbon tetrachloride were contributors at maximum concentrations. At both mean and maximum concentrations, only arsenic produced individual risks above  $1 \times 10^{-4}$ . In downgradient groundwater, exposure to both mean and maximum concentrations produced risks within the USEPA range ( $1 \times 10^{-5}$  and  $3 \times 10^{-5}$ , respectively).

If the modified cancer slope factor (CSF) for arsenic was used to estimate excess lifetime cancer risks for both source area and downgradient groundwater quality, then the cancer risks associated with exposure to both average and maximum concentrations of arsenic in unfiltered and filtered groundwater would fall below  $1 \times 10^{-4}$ .

Estimated noncarcinogenic risks exceeded the USEPA target level of one for both source area and downgradient unfiltered groundwater at mean and maximum concentrations. Hazard Index (HI) for the source area are 25 and 53 for exposure to mean and maximum concentrations, respectively. Benzene, manganese, iron, and arsenic are the primary contributors for source area groundwater. HIs for downgradient groundwater are 2 and 7 for mean and maximum concentrations, respectively. Manganese and benzene are the primary contributors for downgradient groundwater. Individual hazard quotients (HQs) for the primary contributors in both source area and downgradient groundwater all exceed the USEPA target level of one.

For filtered groundwater, estimated noncarcinogenic risks exceeded the USEPA target level of one for both source area and downgradient groundwater at mean and maximum concentrations. HIs for the source area are 24 and 52 for exposure to mean and maximum concentrations, respectively. Benzene and manganese are primary contributors at mean concentrations, while benzene, manganese and arsenic are the primary contributors for maximum concentrations of filtered source area groundwater. HIs for downgradient groundwater are 2 and 6 for

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## EXECUTIVE SUMMARY

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mean and maximum concentrations, respectively. Manganese is the only contributor with an HQ exceeding one.

A comparison of detected concentrations of CPCs in source area and downgradient groundwater to federal and state drinking water standards and guidelines showed several exceedances. In source area groundwater, the following CPCs were detected at concentrations above a federal or state standard or guideline: benzene, ethylbenzene, toluene, carbon tetrachloride, chloroform, naphthalene, arsenic, cadmium, lead, sodium, aluminum, iron, and manganese. In downgradient groundwater, detected concentrations of benzene, chloroform, aluminum, iron, and manganese exceed federal or state drinking water standards or guidelines.

Based on the results and interpretations of the RI and the human health risk assessment, ABB-ES recommends that a FS be performed to evaluate alternatives to reduce potential human health risks associated with potential future exposure to groundwater at the source area directly downgradient of the former UST locations. The FS should also evaluate alternatives to mitigate the migration of source area contaminants to downgradient areas.

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## 1.0 INTRODUCTION

This Remedial Investigation (RI) Report (Data Item A009) for Area of Contamination (AOC) 43J at the Fort Devens U.S. Army Installation (Fort Devens), in north central Massachusetts was prepared by ABB Environmental Services, Inc. (ABB-ES) as a component of Task Order 005 of Contract DAAA15-91-D-008 with the U.S. Army Environmental Center<sup>1</sup> (USAEC). This report details the results of the RI program at AOC 43J, which was completed in accordance with relevant USAEC and U.S. Environmental Protection Agency (USEPA) guidance.

### 1.1 PURPOSE AND SCOPE

The scope of work for the RI at AOC 43J was specified by the USAEC based on previous studies and investigations and USEPA and Massachusetts Department of Environmental Protection (MADEP) comments on prior investigations conducted by ABB-ES at this AOC.

Prior investigations included Fort Devens underground storage tank (UST) removals, Site Investigation (SI) activities, Supplemental SI (SSI) activities, and RI activities. Each phase was undertaken to establish the nature and distribution of site-related contaminants in groundwater and subsurface soil at AOC 43J. These data were collected in order to provide a basis for evaluating and recommending remedial alternatives for potential site remediation, if necessary. The nature of the impacts has been estimated from individual soil and groundwater samples. The following activities were included in the RI investigation:

- Soil sampling and field analysis using ABB-ES's TerraProbe<sup>SM</sup> to further define the horizontal and vertical distribution or soil contamination;

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<sup>1</sup>In January 1993, the U.S. Army Toxic Hazardous Materials Agency (USATHAMA) became the U.S. Army Environmental Center (USAEC). Throughout the RI Report, "USATHAMA" will be used in reference to previous reports that predate this name change.

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## SECTION 1

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- Soil borings and subsurface soil sampling for field and off-site laboratory analysis to supplement the TerraProbe™ investigation;
- Installation of screened auger borings and the sampling of groundwater for field analysis;
- Installation of groundwater monitoring wells and the sampling of groundwater for laboratory analyses;
- Aquifer testing;
- Seismic survey; and
- Vertical and horizontal location surveys.

### 1.2 REPORT ORGANIZATION

Preparation of this RI Report consisted of characterizing the geologic and hydrogeologic conditions and assessing the distribution, migration, potential receptors, and potential effects of identified chemicals on human receptors. The content and presentation of this report relies heavily upon the figures and tables which present the data in the context of exploration locations on site maps. The text within the report supports the figures, and provides detail, interpretation, and analysis that cannot be presented in figures.

After acquiring and evaluating the field and off-site laboratory data and identifying chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs), ABB-ES prepared this RI Report for AOC 43J in accordance with USEPA and USAEC guidance. The report describes the field methods employed, and presents, summarizes, and evaluates the relevant background information, field and laboratory data, results and conclusions from previous investigations, and assesses the potential human health risk.

Section 2.0 of this report describes the history and physical setting of Fort Devens. Section 3.0 summarizes the SI program, including the field procedures, analytical program, QA and QC, and data management. Section 4.0 presents potential

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ARARs and background concentrations of inorganic analytes in soil and groundwater. Section 5.0 of this report summarizes the AOC 43J background and physical conditions, previous investigations, technical objectives of the RI, and RI sampling and investigatory techniques. Section 6.0 presents the interpretation of geologic and hydrogeologic conditions at AOC 43J. Section 7.0 presents the nature and distribution of detected site contaminants, Section 8.0 outlines the fate and transport of the detected site contaminants, Section 9.0 presents the human health baseline risk assessment. Section 10.0 presents the conclusions and recommendations for AOC 43J. Figures and tables associated with each section are presented at the end of each section.

In accordance with the FFA, this RI report will be presented in a Draft version , and after regulatory review, a Final version.

### **1.3 PROJECT OBJECTIVES**

The objective of the project at AOC 43J was to perform an RI in accordance with all relevant MADEP and USEPA guidance and in compliance with USAEC-approved field methods and procedures. The purpose of the RI conducted at AOC 43J was to further define the site contaminants detected in the soil and groundwater during previous site SI and SSI conducted at this AOC, and to determine whether remediation of the site contaminants is warranted.

### **1.4 PROJECT APPROACH**

To meet the project objectives, a significant amount of effort was focused on the production of several RI planning documents. The planning documents were developed in compliance with the appropriate regulatory guidance for remedial investigations, regulatory and USAEC comments, and results of previous investigations.

The project plans were designed to answer data gaps identified from the previous investigations and gather additional data on the physical conditions of the AOC, the nature and distribution of site-related contaminants, and assess the health risks on human receptors.

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### 1.4.1 Project Operations Plan

The principal planning document was the ABB-ES Fort Devens's Project Operations Plan (POP) (ABB-ES, 1992a; 1993d), which provides detailed descriptions and discussions of the elements essential to conducting field investigation activities. The POP was revised between the 1992 SI and 1993 SSI field investigation to include new sampling techniques. The purpose of this plan was to define responsibilities and authorities for data quality, and to define requirements such that the field investigation activities undertaken by ABB-ES at Fort Devens would be planned and executed in a manner consistent with USAEC quality assurance (QA) program objectives. The POP includes the specified elements of a Sampling and Analysis Plan (SAP) and Health and Safety Plan (HASP). The SAP includes the essential elements of the Quality Assurance Project Plan (QAPP) and the Field Sampling Plan. USEPA has prepared guidance on the preparation of a POP in "Guidance for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring"; (USEPA, 1984). The guidance was designed to eliminate the necessity for preparation of multiple, redundant documents.

The requirements of the POP were applied to ABB-ES and subcontractor activities related to the collection of environmental data at Fort Devens. The POP adheres to the requirements and guidelines contained in the "USAEC QA Program, January 1990" for collection and analysis of samples and the USAEC "Geotechnical Requirements for Drilling, Monitoring Wells, Data Acquisition, and Reports, March 1987" for the installation of borings and monitoring wells, and for land survey location. In addition, the POP meets guidelines of USAEC chain-of-custody (COC) procedures.

The ABB-ES Fort Devens POP provides guidance and specifications to ensure that samples are obtained under controlled conditions using appropriate, documented procedures; and that samples are identified uniquely and controlled through sample tracking systems and COC protocols. The POP also includes specifications to ensure that field determinations and laboratory analytical results are of known quality and are valid, consistent, and compatible with the USAEC chemical data base through the use of certified methods, preventive maintenance, calibration, and analytical protocols, quality control (QC) measurements, review, correction of out-of-control situations, and audits. The POP also specifies the

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methods and procedures to be used to ensure that calculations and evaluations are accurate, appropriate, and consistent throughout the projects; generated data are validated and their use in calculations is documented; and records are retained as documentary evidence of the quality of samples, applied processes, equipment, and results.

The HASP was prepared as an integral element of the POP in accordance with the same schedule and review requirements (ABB-ES, 1992a; 1993d, Appendix A). The HASP complies with USAEC's EM 385-1-1, AMC-R-385-100, and Fort Devens safety requirements, as well as Occupational Safety and Health Administration (OSHA) Regulations 29 CFR 1910.120. The HASP development was based on appropriate information contained in previous investigation documents from Fort Devens. The HASP portion of the POP ensures that health and safety procedures are maintained by requiring inclusion of the health and safety staff function in the project organization.

#### **1.4.2 Task Order Work Plan**

The background, rationale, and specific scope for the RI are set forth in a second companion planning document, the Task Order Work Plan. The Revised Final Task Order Work Plan for AOC 43J was prepared under a modification to Contract DAAA15-91-D-0008 Task Order No. 005 (ABB-ES, 1994b). The Revised Final Task Order Work Plan was developed to comply with the Massachusetts Contingency Plan (MCP) (310 Code of Massachusetts Regulations [CMR] 40.000); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986; the corrective action provisions of the Hazardous and Solid Waste Amendments; and the Toxic Substances Control Act. Work conducted under the Revised Final Task Order Work Plan was performed in accordance with the provisions of the Federal Facility Agreement (FFA) (USEPA and U.S. Army, 1991) and USAEC guidelines.

The background information provided in the Revised Final Task Order Work Plan for AOC 43J was based largely on information in the Master Environmental Plan (MEP), review of installation documents, observations made during site visits conducted by ABB-ES, interviews with installation personnel, and previous investigations. Summaries of each of these activities and discussions of specific

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field activities to be conducted under this modification to Task Order 005 were included in the Revised Final Task Order Work Plan. The discussions focused specifically on the objectives and scope of proposed RI activities.

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## **2.0 INSTALLATION DESCRIPTION**

Fort Devens is located in the towns of Ayer and Shirley (Middlesex County) and Harvard and Lancaster (Worcester County), approximately 35 miles northwest of Boston, Massachusetts. It lies within the Ayer, Shirley, and Clinton map quadrangles (7½-minute series). The installation occupies approximately 9,260 acres and is divided into the North Post, the Main Post, and the South Post (Figure 2-1).

Over 6,000 acres at Fort Devens are used for training and military maneuvers, and over 3,000 acres are developed for housing, buildings, and other facilities; the installation has been reported as the largest undeveloped land holding under a single owner in north-central Massachusetts (United States Fish and Wildlife Service [USFWS], 1992).

The South Post is located south of Massachusetts Route 2 and is largely undeveloped. The Main Post and North Post primarily contain developed lands, including recreational areas (e.g., a golf course and Mirror Lake), training areas, and an airfield. AOC 43J is located on the Main Post (Figure 2-2).

The following subsections describe the history and physical setting of Fort Devens.

### **2.1 HISTORY**

Camp Devens was created as a temporary cantonment in 1917 for training soldiers from the New England area. It was named after Charles Devens -- a Massachusetts Brevet Major General in the Union Army during the Civil War who later became Attorney General under President Rutherford Hayes. Camp Devens served as a reception center for selectees, as a training facility, and, at the end of World War I, as a demobilization center (Marcoa Publishing Inc., 1990). At Camp Devens the 1918 outbreak of Spanish influenza infected 14,000 people, killed 800, and caused the installation to be quarantined (McMaster et al., 1982). Peak military strength during World War I was 38,000. After World War II,

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Camp Devens became an installation of the U.S. Army Field Forces, CONARC in 1962, and the U.S. Army Forces Command in 1973 (Biang et al., 1992).

In 1921, Camp Devens was placed in caretaker status. During summers from 1922 to 1931, it was used as a training camp for National Guard troops, Reserve units, Reserve Officer Training Corps cadets, and the Civilian Military Training Corps. In 1929, Dr. Robert Goddard used Fort Devens to test his early liquid-fuel rockets, and there is a monument to him on Sheridan Road near Jackson Gate (Fort Devens Dispatch, 1992).

In 1931, troops were again garrisoned at Camp Devens. It was declared a permanent installation, and in 1932 was formally dedicated as Fort Devens. During the 1930s, there was a limited building program, and beautification projects were conducted by the Works Progress Administration (WPA) and Civilian Conservation Corps.

In 1940, Fort Devens became a reception center for New England draftees. It expanded to more than 10,000 acres. Approximately 1,200 wooden buildings were constructed, and two 1,200-bed hospitals were built. In 1941, the Army Airfield was constructed by the WPA in a period of 113 days (Fort Devens Dispatch, 1992). In 1942, the Whittemore Service Command Base Shop for motor vehicle repair (Building 3713) was built, and at the time it was known as the largest garage in the world (U.S. Army, 1979). The installation's current wastewater treatment plant was also constructed in 1942 (Biang et al., 1992).

During World War II, more than 614,000 inductees were processed. Fort Devens' population reached a peak of 65,000. Three Army divisions and the Fourth Women's Army Corps trained at Fort Devens, and it was the location of the Army's Chaplain School, the Cook & Baker School, and a basic training center for Army nurses. A prisoner of war camp for 5,000 German and Italian soldiers was operated from 1944 to 1946. At the end of the war, Fort Devens again became a demobilization center, and in 1946 it reverted to caretaker status.

Fort Devens was reactivated in July 1948 and again became a reception center during the Korean Conflict. It has been an active Army facility since that time.

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Currently, the mission at Fort Devens is to command and train its assigned duty units, operate the South Boston Support Activity in Boston, Massachusetts, the Sudbury Training Annex, and the Hingham U.S. Army Reserve (USAR) Annex, and support the 10th Special Forces Group (A), the U.S. Army Intelligence School, Fort Devens, the U.S. Army Reserves, Massachusetts Army National Guard, and Reserve Officer Training Programs. No major industrial operations occur at Fort Devens, although several small-scale industrial operations are performed under the Directorate of Plans, Training, and Security; the Directorate of Logistics; and the Directorate of Engineering and Housing. The major waste-producing operations performed by these groups are photographic processing and maintenance of vehicles, aircraft, and small engines. Past artillery fire, mortar fire, and waste explosive disposal at Fort Devens are potential sources for explosives contamination (USAEC, 1993).

Under Public Law 101-510, the Base Realignment and Closure Act (BRAC) 1990, Fort Devens has been identified for closure by July 1997, and 4,600 acres are to be retained to establish a Reserve Component enclave and regional training center.

## **2.2 PHYSICAL SETTING**

The climate, vegetation, ecology, physiography, soils, surficial and bedrock geology, and regional hydrogeology of Fort Devens are described in the subsections that follow.

### **2.2.1 Climate**

The climate of Fort Devens is typical of the northeastern United States, with long cold winters and short hot summers. Climatological data were reported for Fort Devens by U.S. Department of the Army (1979), based in part on a 16-year record from Moore Army Airfield (MAAF).

The mean daily minimum temperature in the coldest months (January and February) is 17 degrees Fahrenheit (°F), and the mean daily maximum temperature in the hottest month (July) is 83°F. The average annual temperature

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is 58°F. There are normally 12 days per year when the temperature reaches or exceeds 90°F and 134 days when it falls to or below freezing.

The average annual rainfall is 39 inches. Mean monthly precipitation varies from a low of 2.3 inches (in June) to a high of 5.5 inches (in September). The average annual snowfall is 65 inches, and snowfall has been recorded in the months of September through May (falling most heavily from December through March).

Wind speed averages 5 miles per hour (mph), ranging from the highest monthly average of 7 mph (March-April) to the lowest monthly average of 4 mph (September).

Average daytime relative humidities range from 71 percent (January) to 91 percent (August), and average nighttime relative humidities range from 46 percent (April) to 60 percent (January).

### 2.2.2 Vegetation

The Main and North Posts at Fort Devens are primarily characterized by urban and developed cover types. Approximately 56 percent of these areas are covered by developed lands, the golf course, the airfield, and the wastewater infiltration beds. Early successional forest cover types (primarily black cherry-aspen hardwoods) cover approximately 2 percent of the area, mixed oak-red maple hardwoods approximately 20 percent, and white pine-hardwood mixes approximately 11 percent. The rest of the North and Main Posts are characterized by various coniferous species, shrub habitat, and herbaceous cover types.

Much of the South Post is undeveloped forested land. The area includes approximately 8 percent early successional forest (black cherry, red birch, grey birch, quaking aspen, red maple); 26 percent mixed oak hardwoods; and 9 percent coniferous forest (white pine, pitch pine, red pine). Four percent of the area comprises a mixed shrub community. The 200-acre Turner Drop Zone is maintained as a grassland that represents a "prairie" habitat. Vegetative cover in the large "impact area" of the central South Post has not been mapped in detail. It is dominated by fire-tolerant species such as pitch pine and scrub oak.

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Extensive sandy glaciofluvial soils are found in the Nashua River Valley, particularly in the South and North Post areas of Fort Devens. Extensive accumulations of these soils are unusual in Massachusetts outside of Cape Cod and adjacent areas of southeastern Massachusetts, and they account for some of the floral and faunal diversity at the installation.

### **2.2.3 Ecology**

Fort Devens encompasses numerous terrestrial, wetland, and aquatic habitats in various successional stages. Floral and faunal diversity is strengthened by the installation's close proximity to the Nashua River; the amount, distribution, and nature of wetlands; and the undeveloped state and size of the South Post (USFWS, 1992). Much of Fort Devens was formerly agricultural land and included pastures, woodlots, orchards, and cropped fields. Existing habitat types reflect this agrarian history, ranging from abandoned agricultural land to secondary growth forested regions. Fort Devens is generally reverting back to a forested state.

There are 1,313 acres of wetlands at Fort Devens. The wetlands are primarily palustrine, although riverine and lacustrine types are also found. Forested palustrine floodplain wetlands associated with the Nashua River and its tributary Nonacoicus Brook are located on Fort Devens' Main and North Posts. These include 191 acres of flooded areas, emergent marsh, and shrub wetlands. Also present are 245 acres of isolated regions of palustrine wetlands and lacustrine systems. On the South Post, there are 877 acres of wetlands, consisting of deciduous forested wetlands, deciduous shrub swamps, emergent marsh, open lacustrine waters in ponds, and open riverine waters.

Approximately half of Fort Devens' land area abuts the northern boundary of the Oxbow National Wildlife Refuge (NWR), a federal resource administered as part of the Great Meadows NWR (USFWS, 1992).

Fort Devens supports an abundance and diversity of wildlife. Identified taxa include 771 vascular plant species, 538 species of butterflies and moths, eight tiger beetle species, 30 vernal pool invertebrates, 15 amphibian species (six salamanders, two toads, seven frogs), 19 reptile species (seven turtles, 12 snakes),

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152 bird species, and 42 mammal species. The status of fish populations in Fort Devens aquatic systems has not been fully defined.

Rare and endangered species at Fort Devens include the federally listed (endangered) bald eagle and peregrine falcon (both occasional transients); the state-listed (endangered) upland sandpiper, ovoid spike rush, and Houghton's flatsedge; the state-listed (threatened) Blanding's turtle, cattail sedge, pied-billed grebe, and northern harrier; and the state-listed (special concern) blue-spotted salamander, grasshopper sparrow, spotted turtle, wood turtle, water shrew, blackpoll warbler, American bittern, Cooper's hawk, sharp-shinned hawk, and Mystic Valley amphipod. Also state-listed as rare or endangered are three Lepidoptera (butterfly and moth) species identified at Fort Devens.

The Massachusetts Natural Heritage Program has developed Watch Lists of unprotected species that are uncommon or rare in Massachusetts. From the Watch Lists, 14 plant species, two amphibian species, and 15 bird species have been observed at Fort Devens.

### 2.2.4 Physiography

Fort Devens is in a transitional area between the coastal lowland and central upland regions of Massachusetts. All of the landforms are products of glacial erosion and deposition on a crystalline bedrock terrain. Glacial erosion was superimposed on ancient bedrock landforms that were developed by the erosional action of preglacial streams. Generally, what were bedrock hills and ridges before the onset of Pleistocene glaciation were only moderately modified by glacial action, and they remain bedrock hills and ridges today. Similarly, preglacial bedrock valleys are still bedrock valleys. In post-glacial time, streams have locally modified the surficial glacial landforms but generally have not affected bedrock.

The predominant physiographic (and hydrologic) feature in the Fort Devens area is the Nashua River (see Figure 2-1). It forms the eastern installation boundary on the South Post, where its valley varies from a relatively narrow channel (at Still River Gate), to an extensive floodplain with a meandering river course and numerous cutoff meanders (at Oxbow National Wildlife Sanctuary). The Nashua River forms the western boundary of much of the Main Post, and there its valley is deep and comparatively steep-sided with extensive bedrock outcroppings on the

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eastern bank. The river flows through the North Post in a well-defined channel within a broad forested floodplain.

Terrain at Fort Devens falls generally into three types. The least common is bedrock terrain, where rocks that have been resistant to both glacial and fluvial erosion remain as topographic highs, sometimes thinly veneered by glacial deposits. Shepley's Hill on the Main Post is the most prominent example.

A similar but more common terrain at Fort Devens consists of materials (tills) deposited directly by glaciers as they advanced through the area or as the ice masses wasted (melted). These landforms often conform to the shape of the underlying bedrock surface. They range from areas of comparatively low topographic relief (such as near Lake George Street on the Main Post) to elongated hills (drumlins) whose orientations reflect the direction of glacier movement (such as Whittemore Hill on the South Post). The area around AOC 43J is comprised of this type of terrain.

The third type of terrain was formed by sediment accumulations in glacial-meltwater streams and lakes (glaciofluvial and glaciolacustrine deposits). This is the most common terrain at Fort Devens, comprising most of the North and South Posts and much of the Main Post. Its form bears little or no relationship to the shape of the underlying bedrock surface. Landforms include extensive flat uplands such as the hills on which MAAF and the wastewater infiltration beds are located on the North Post. Those are large remnants of what was once a continuous surface that was later incised and divided by downcutting of the Nashua River. Another prominent glacial meltwater feature is the area around Cranberry Pond and H-Range on the South Post. This is classic kame-and-kettle topography formed by sand and gravel deposition against and over large isolated ice blocks, followed by melting of the ice and collapse of the sediments. The consistent elevations of the tops of these ice-contact deposits are an indication of the glacial-lake stage with which they are associated. Mirror Lake and Little Mirror Lake on the Main Post occupy another conspicuous kettle.

### **2.2.5 Soils**

Fort Devens lies within Worcester County and Middlesex County in Massachusetts (see Figure 2-1). The soils of Worcester County have been mapped by the Soil

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Conservation Service (SCS) of the U.S. Department of Agriculture (USDA) (SCS, 1985). Mapping of the soils of Middlesex County has not been completed. However, an interim report (SCS, 1991), field sheet #19 (SCS, 1989), and an unpublished general soil map (SCS, undated) are available.

Soil mapping units ("soil series") that occur together in intricate characteristic patterns in given geographic areas are grouped into soil "associations." Soils in the Worcester County portions of Fort Devens consist generally of three associations. Three associations also have been mapped in the Middlesex County portions of Fort Devens. Although the mapped associations are not entirely the same on both sides of the county line, the differences reflect differences in definition and the interim status of Middlesex County mapping. The general distributions of the soil associations are shown in Figure 2-3, and descriptions of the soil series in those associations are provided below.

### **WORCESTER COUNTY (SCS, 1985)**

#### Winooski-Limerick-Saco Association:

Winooski Series. Very deep; moderately well-drained; slopes 0 to 3 percent; occurs on floodplains; forms in silty alluvium.

Limerick Series. Very deep; poorly drained; slopes 0 to 3 percent; occurs on floodplains; forms in silty alluvium.

Saco Series. Very deep; very poorly drained; slopes 0 to 3 percent; occurs on floodplains; derived mainly from schist and gneiss.

#### Hinckley-Merrimac-Windsor Association:

Hinckley Series. Very deep; excessively drained; slopes 0 to 35 percent; occurs on stream terraces, eskers, kames, and outwash plains.

Merrimac Series. Very deep; excessively drained; slopes 0 to 25 percent; occurs on stream terraces, eskers, kames, and outwash plains.

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Windsor Series. Very deep; moderately well-drained; slopes 0 to 3 percent; occurs on floodplains.

Paxton-Woodbridge-Canton Association:

Paxton Series. Very deep; well-drained; slopes 3 to 35 percent; occurs on glacial till uplands; formed in friable till overlying firm till.

Woodbridge Series. Very deep; moderately well-drained; slopes 0 to 15 percent; occurs on glacial till uplands; formed in firm till.

Canton Series. Very deep; well-drained; slopes 3 to 35 percent; occurs on glacial uplands; formed in friable till derived mainly from gneiss and schist.

**MIDDLESEX COUNTY (SCS, 1991)**

Hinckley-Freetown-Windsor Association: The soils at AOC 43J are comprised of this soil type (See Figure 2-3). (This is a continuation of the Hinckley-Merrimac-Windsor Association mapped in Worcester County):

Hinckley Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash terraces, kames, and eskers; formed in gravelly and cobbly coarse textured glacial outwash.

Freetown Series. Deep; very poorly drained; nearly level, organic; occurs in depressions and on flat areas of uplands and glacial outwash plains.

Windsor Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash plains, terraces, deltas, and escarpments; formed in sandy glacial outwash.

Quonset-Carver Association:

Quonset Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash plains, terraces, eskers, and kames; formed in water-sorted sands derived principally from dark phyllite, shale, or slate.

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Carver Series. Deep; excessively drained; nearly level to steep; occurs on glacial outwash plains, terraces, and deltas; formed in coarse, sandy, water-sorted material.

Winooski-Limerick-Saco Association: (This is a continuation of the same association mapped along the Nashua River floodplain in Worcester County).

### 2.2.6 Surficial Geology

Fort Devens lies in three topographic quadrangles: Ayer, Clinton, and Shirley. The surficial geology of Fort Devens has been mapped only in the Ayer quadrangle (Jahns, 1953) and Clinton quadrangle (Koteff, 1966); the Shirley quadrangle is unmapped.

Unconsolidated surficial deposits of glacial and postglacial origin comprise nearly all of the exposed geologic materials at Fort Devens. The glacial units consist of till, deltaic deposits of glacial Lake Nashua, and deposits of glacial meltwater streams.

The superficial geology at AOC 43J can be placed in the following geologic setting. The till ranges from unstratified gravel to silt, and it is characteristically bouldery. Jahns (1953) and Koteff (1966) recognize a deeper unit of dense, subglacial till, and an upper, looser material that is probably a slightly younger till of englacial or superglacial origin. Till is exposed in ground-moraine areas of the Main Post (such as in the area of Lake George Street) and on the South Post at and south of Whittemore Hill. It also underlies some of the water-laid deposits (Jahns, 1953). Till averages approximately 10 feet in thickness but reaches 60 feet in drumlin areas (Koteff, 1966).

Most of the surficial glacial units in the Nashua Valley are associated with deposition in glacial Lake Nashua, which formed against the terminus of the Wisconsin ice sheet as it retreated northward along the valley. Successively lower outlets were uncovered by the retreating glacier, and the lake level was correspondingly lowered. Koteff (1966) and Jahns (1953) recognize six lake levels (stages) in the Fort Devens area, distinguished generally by the elevations and distribution of their associated deposits. The stages are, in order of development:

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Clinton Stage; Pin Hill Stage; Old Mill Stage; Harvard Stage; Ayer Stage; and Groton Stage.

The glacial lake deposits consist chiefly of sand and gravelly sand. Coarser materials are found in topset beds of deltas built out into the lakes and in glacial stream beds graded to the lakes. Delta foreset beds are typically composed of medium to fine sand, silt, and clay. Lake-bottom deposits, which consist of fine sand, silt, and clay, are mostly covered by delta deposits and are seldom observed in glacial Lake Nashua deposits. One of the few known exposures of glacial lake-bottom sediments in the region is on the South Post near A- and C-Ranges. There, a section of more than 14 feet of laminated clay was mined for brick-making in the early part of this century (Alden, 1925, pp. 70-71). The general physical characteristics of glacial lake deposits are the same regardless of the particular lake stage in which the deposits accumulated (Koteff, 1966; Jahns, 1953). Although glaciofluvial and glaciolacustrine sediments are typically well stratified, correlations between borings are difficult because of laterally abrupt changes characteristic of these generally high-energy depositional environments.

Postglacial deposits consist mostly of river-terrace sands and gravels; fine alluvial sands and silts beneath modern floodplains; and muck, peat, silt, and sand in swampy areas.

Jahns (1953) also observed a widespread veneer of windblown sand and ventifacts above the glacial materials (and probably derived from them in the brief interval between lake drainage and the establishment of vegetative cover).

### **2.2.7 Bedrock Geology**

Fort Devens is underlain by low-grade metasedimentary rocks, gneisses, and granites. The rocks range in age from Late Ordovician to Early Devonian (approximately 450 million to 370 million years old). The installation is situated approximately 2 miles west of the Clinton-Newbury-Bloody Bluff fault zone, that developed when the ancestral European continental plate collided with and underthrust the ancestral North American plate. The continents resealed in the Mesozoic to form the modern Atlantic Ocean. Fort Devens is located on the very eastern edge of the ancestral North American continental plate. A piece of

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the ancestral European continent (areas now east of the Bloody Bluff fault) broke off and remained attached to North America.

Preliminary bedrock maps (at scale 2,000 feet/inch) are available for the Clinton quadrangle (Peck, 1975 and 1976) and Shirley quadrangle (Russell and Allmendinger, 1975; Robinson, 1978). Bedrock information for the Ayer quadrangle is from the Massachusetts state bedrock map (at a regional scale of 4 miles/inch) (Zen, 1983) and in associated references (Robinson and Goldsmith, 1991; Wones and Goldsmith, 1991). Among these sources, there is some disagreement about unit names and stratigraphic sequence; however, there is general agreement about the distribution of rock types.

In contrast to the high metamorphic grade and highly sheared rocks of the Clinton-Newbury zone, the rocks in the Fort Devens area are low grade metamorphics (generally below the biotite isograd) and typically exhibit less brittle deformation. Major faults have been mapped, however, including the Wekepeke fault exposed west of Fort Devens (in an outcrop 0.25 mile west of the old Howard Johnson rest stop on Route 2).

Figure 2-4 is a generalized summary of the bedrock geology of Fort Devens. It is compiled from Peck (1975), Robinson (1978), Russell and Allmendinger (1975), and Zen (1983), and it adopts the nomenclature of Zen (1983). Because of limited bedrock exposures, the locations of mapped contacts are considered approximate, and the mapped faults are inferred. Rock units strike generally northward to northeastward but vary locally. The bedrock units underlying Fort Devens are as follows:

- DSw WORCESTER FORMATION (Lower Devonian and Silurian)**  
Carbonaceous slate and phyllite, with minor metagraywacke to the west (Zen, 1983; Peck, 1975). Bedding is typically obscure due to a lack of compositional differences. It is relatively resistant to erosion and forms locally prominent outcrops. The abandoned Shaker slate quarry on the South Post is in rocks of the Worcester Formation. The unit corresponds to the "DSgs" and "DSs" units of Peck (1975) and the "e3" unit of Russell and Allmendinger (1975).

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- So OAKDALE FORMATION** (Silurian) Metasiltstone and phyllite. It is fine-grained and consists of quartz and minor feldspar and ankerite, and it is commonly deformed by kink banding (Zen, 1983; Peck, 1975; Russell and Allmendinger, 1975). In outcrop it has alternating layers of brown siltstone and greenish phyllite. The Oakdale Formation crops out most visibly on Route 2 just east of the Jackson Gate exit. It corresponds to the "DSsp" unit of Peck (1975), the "e2" unit of Russell and Allmendinger (1975), and "ms" unit of Robinson (1978). The bedrock at AOC 43J is classified as part of this formation (see Figure 2-4).
- Sb BERWICK FORMATION** (Silurian) Thin- to thick-bedded metamorphosed calcareous metasiltstone, biotitic metasiltstone, and fine-grained metasandstone, interbedded with quartz-muscovite-garnet schist and feldspathic quartzite (Zen, 1983; Robinson and Goldsmith, 1991). In areas northwest of Fort Devens, cataclastic zones have been observed (Robinson, 1978).
- Dcgr CHELMSFORD GRANITE** (Lower Devonian) Light-colored and gneissic, even and medium-grained, quartz-microcline-plagioclase-muscovite-biotite, pervasive ductile deformation visible in elongate quartz grains aligned parallel to mica. It intrudes the Berwick Formation and Ayer granite (Wones and Goldsmith, 1991).
- AYER GRANITE**
- Sacgr Clinton facies** (Lower Silurian) Coarse-grained, porphyritic, foliated biotite granite with a nonporphyritic border phase; it intrudes the Oakdale and Berwick Formations and possibly the Devens-Long Pond Facies (Zen, 1983; Wones and Goldsmith, 1991).
- SOad Devens-Long Pond facies** (Upper Ordovician and Lower Silurian) Gneissic, equigranular to porphyroblastic biotite granite and granodiorite. Its contact relationship with the Clinton facies is unknown (Wones and Goldsmith, 1991). Observations of mapped exposures of this unit on Fort Devens indicate that it may not be intrusive.

## SECTION 2

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Bedrock is typically unweathered to only slightly weathered at Fort Devens. Glaciers stripped away virtually all of the preglacially weathered materials, and there has been insufficient time for chemical weathering of rocks in the comparatively brief geologic interval since glacial retreat.

### 2.2.8 Regional Hydrogeology

Fort Devens is in the Nashua River drainage basin, and the Nashua River is the eventual discharge locus for all surface water and groundwater flow at the installation.

The water of the Nashua River has been assigned to Class B under Commonwealth of Massachusetts regulations. Class B surface water is "designated for the uses of protection and propagation of fish, other aquatic life and wildlife, and for primary and secondary contact recreation" (314 CMR 4.03).

The principal tributaries of the north-flowing Nashua River at Fort Devens are Nonacoicus Brook and Walker Brook on the North Post; Cold Spring Brook (which is a tributary of Nonacoicus Brook) on the Main Post; and Spectacle Brook and Ponakin Brook (tributaries of the North Nashua River), Slate Rock Brook, and New Cranberry Pond Brook on the South Post (see Figure 2-5).

There are two ponds on Fort Devens' South Post that are called Cranberry Pond. For the purpose of the SIs, the isolated kettle pond located east of H-Range is referred to as Cranberry Pond, and the pond impounded in the 1970s 0.5-mile west of the Still River gate is referred to as New Cranberry Pond.

Glacial meltwater deposits constitute the primary aquifer at Fort Devens. In aquifer tests performed as part of the SIs (refer to Appendix A), measured hydraulic conductivities in meltwater deposits were comparatively high - typically  $10^{-3}$  to  $10^{-2}$  centimeters per second (cm/sec). In till and in clayey lake-bottom sediments, measured hydraulic conductivities were lower and ranged generally from  $10^{-6}$  to  $10^{-4}$  cm/sec. Groundwater also occurs in the underlying bedrock; however, flow is limited because the rocks have no primary porosity and water moves only in fractures and dissolution voids.

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Groundwater in the surficial aquifer at Fort Devens has been assigned to Class I under Commonwealth of Massachusetts regulations. Class I consists of groundwaters that are "found in the saturated zone of unconsolidated deposits or consolidated rock and bedrock and are designated as a source of potable water supply" (314 CMR 6.03).

The transmissivity of an aquifer is the product of its hydraulic conductivity and saturated thickness, and as such it is a good measure of groundwater availability. Figure 2-5 shows aquifer transmissivities at Fort Devens, based on the regional work of Brackley and Hansen (1977). Transmissivities in the meltwater deposits range from 10 square feet per day ( $\text{ft}^2/\text{day}$ ) to more than 4,000  $\text{ft}^2/\text{day}$ . Aquifer transmissivities between 10 and 1,350  $\text{ft}^2/\text{day}$  correspond to potential well yields generally between 10 and 100 gallons per minute (gpm); transmissivities from 1,350 to 4,000  $\text{ft}^2/\text{day}$  typically yield from 100 to 300 gpm; and where transmissivities exceed 4,000  $\text{ft}^2/\text{day}$ , well yields greater than 300 gpm can be expected. (Most domestic wells in the area are drilled 100 to 200 feet into bedrock and yield less than 10 gpm. Higher yields are associated with deeper bedrock wells.)

In Figure 2-5, the zones of highest transmissivity are found in areas of thick glacial meltwater deposits on the North and Main Posts, and these encompass the Sheboken, Patton, and McPherson production wells and the largely inactive Grove Pond well-field. The zones of lowest transmissivity are associated with exposed till and bedrock and are located on the Main Post surrounding Shepley's Hill and between Jackson Gate and the parade ground (AOC 43J is located in this area, (see Figure 2-5), and on the South Post at Whittemore Hill and isolated areas to the north and west.

A regional study of water resources in the Nashua River basin was reported by Brackley and Hansen (1977). A digital model of groundwater flow at Fort Devens is available in a draft final report by Engineering Technologies Associates, Inc. (ETA) (1992).

According to ETA (1992), in the absence of pumping or other disturbances, groundwater recharge occurs in upland areas (e.g., the high ground on the Main Post between Queenstown, Givry, and Lake George Streets (AOC 43J is located in this area of the Main Post), and on the South Post the area around Whittemore

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## **SECTION 2**

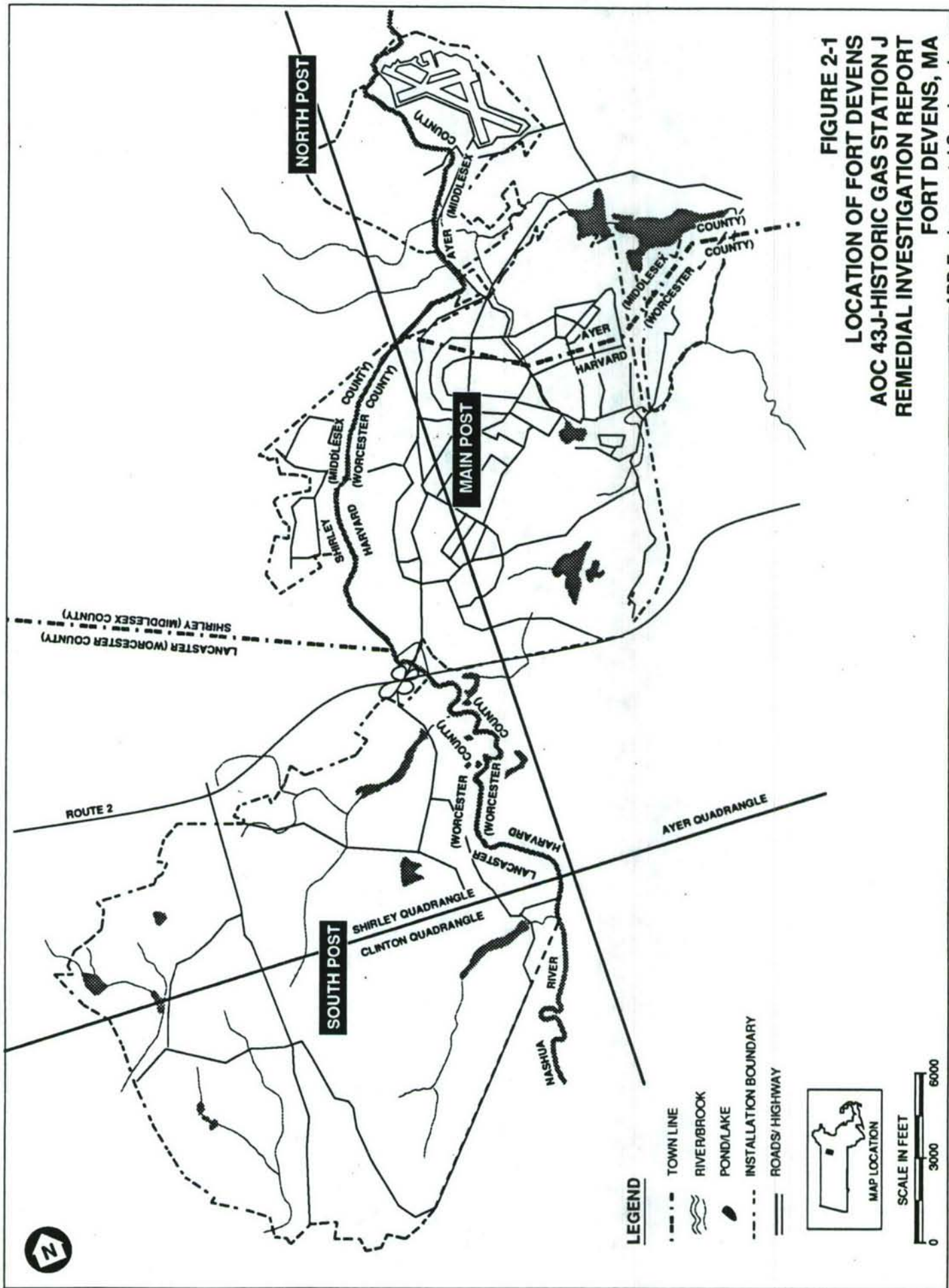
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Hill). The groundwater flows generally from the topographic highs to topographic lows. It discharges in wetlands, ponds, streams, and directly into the Nashua River. Groundwater discharge maintains the dry-weather flow of the rivers and streams. Figures 2-6 and 2-7, respectively, present ETA's regional overburden and bedrock groundwater flow maps (ETA, 1992).

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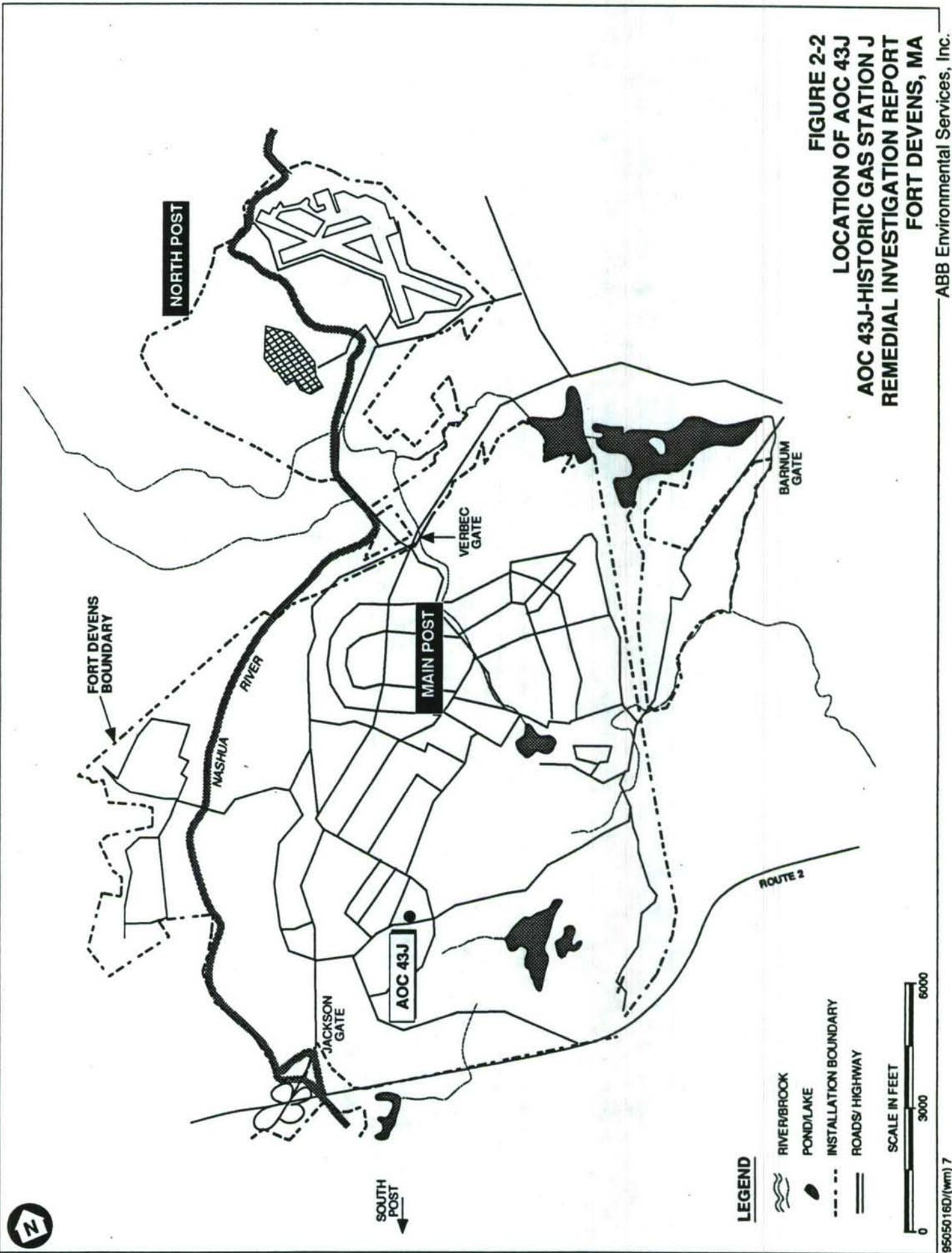




**FIGURE 2-1**  
**LOCATION OF FORT DEVENS**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**  
 ABB Environmental Services, Inc.

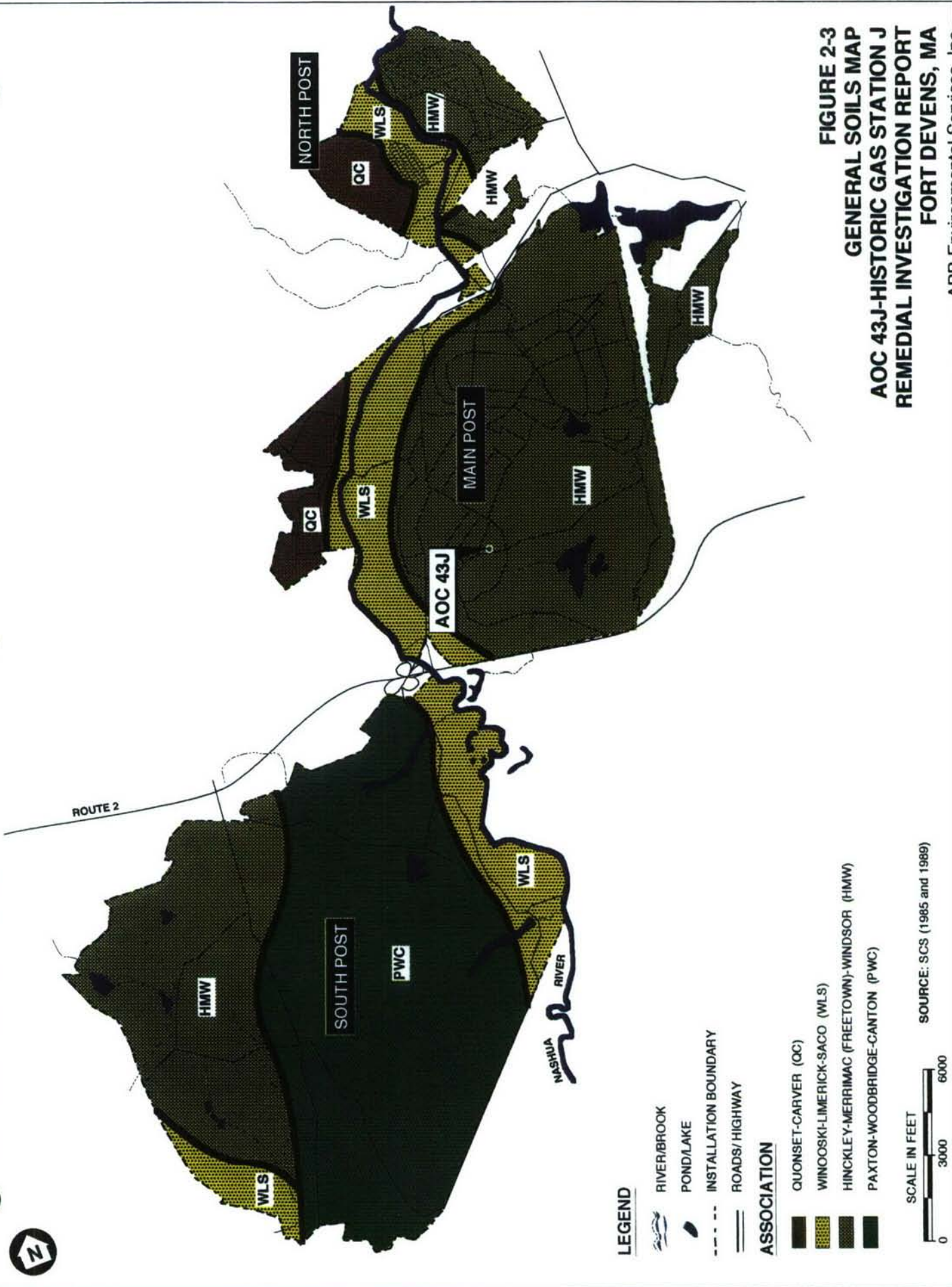








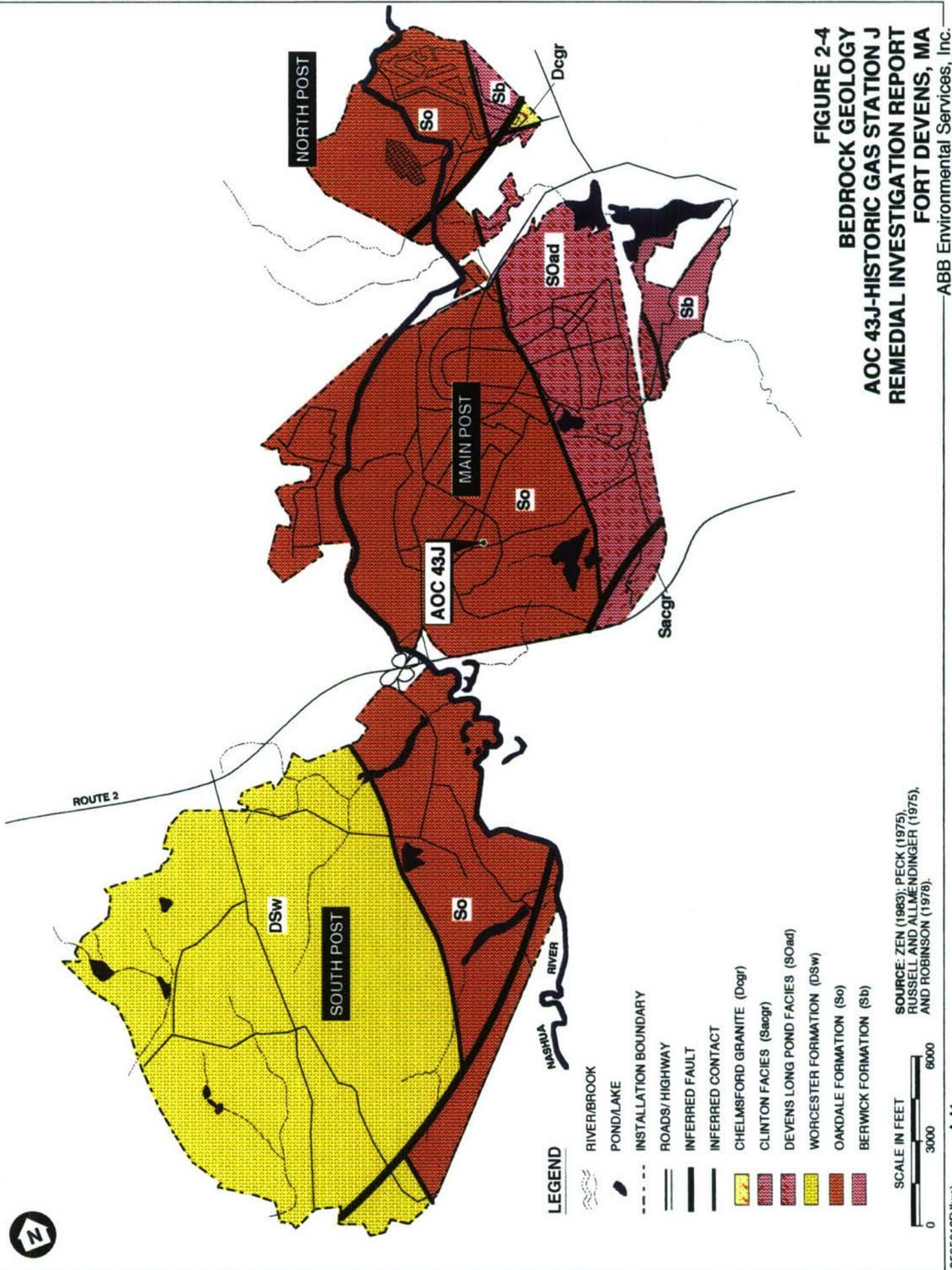




**FIGURE 2-3**  
**GENERAL SOILS MAP**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**  
 ABB Environmental Services, Inc.

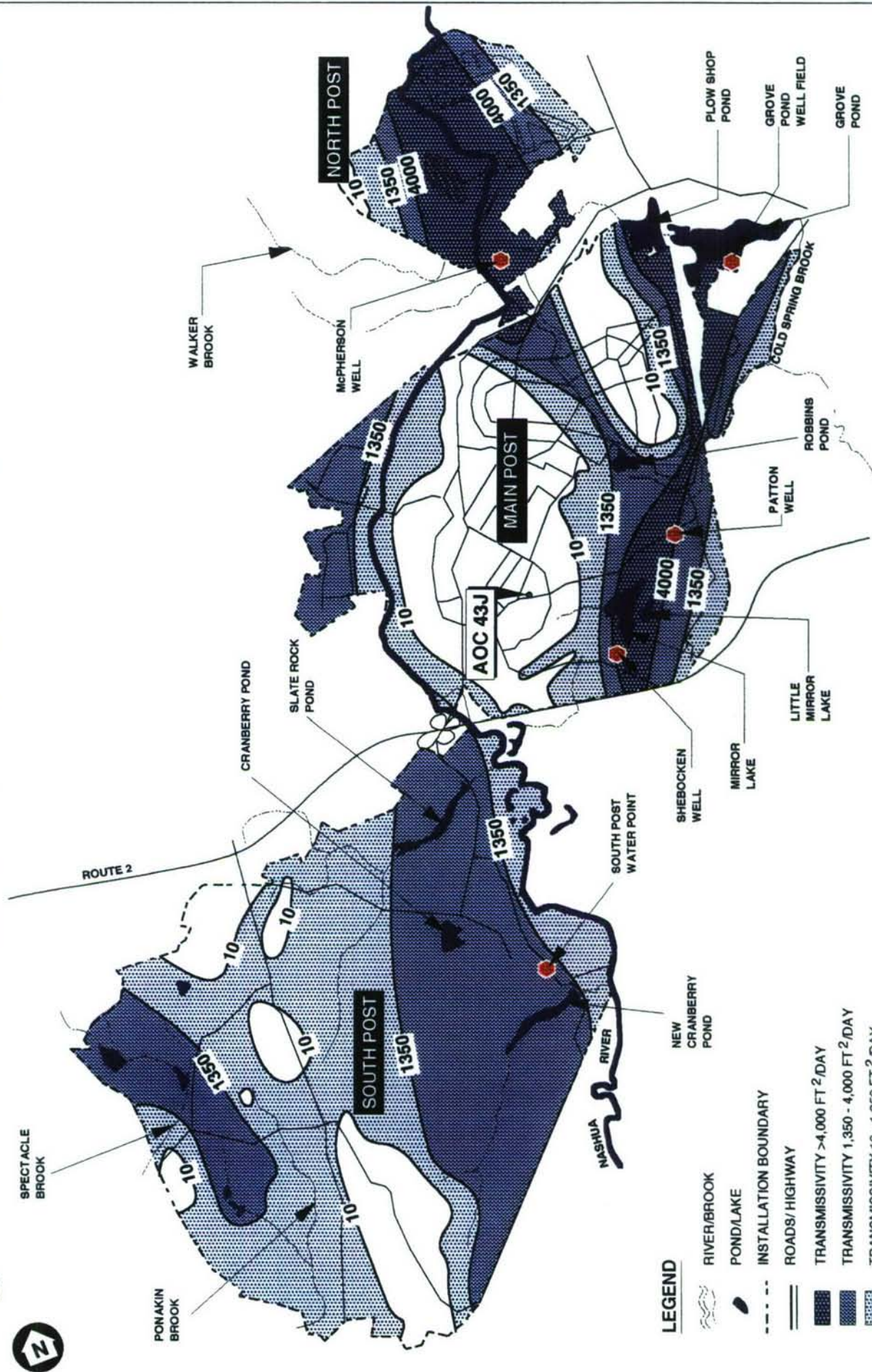






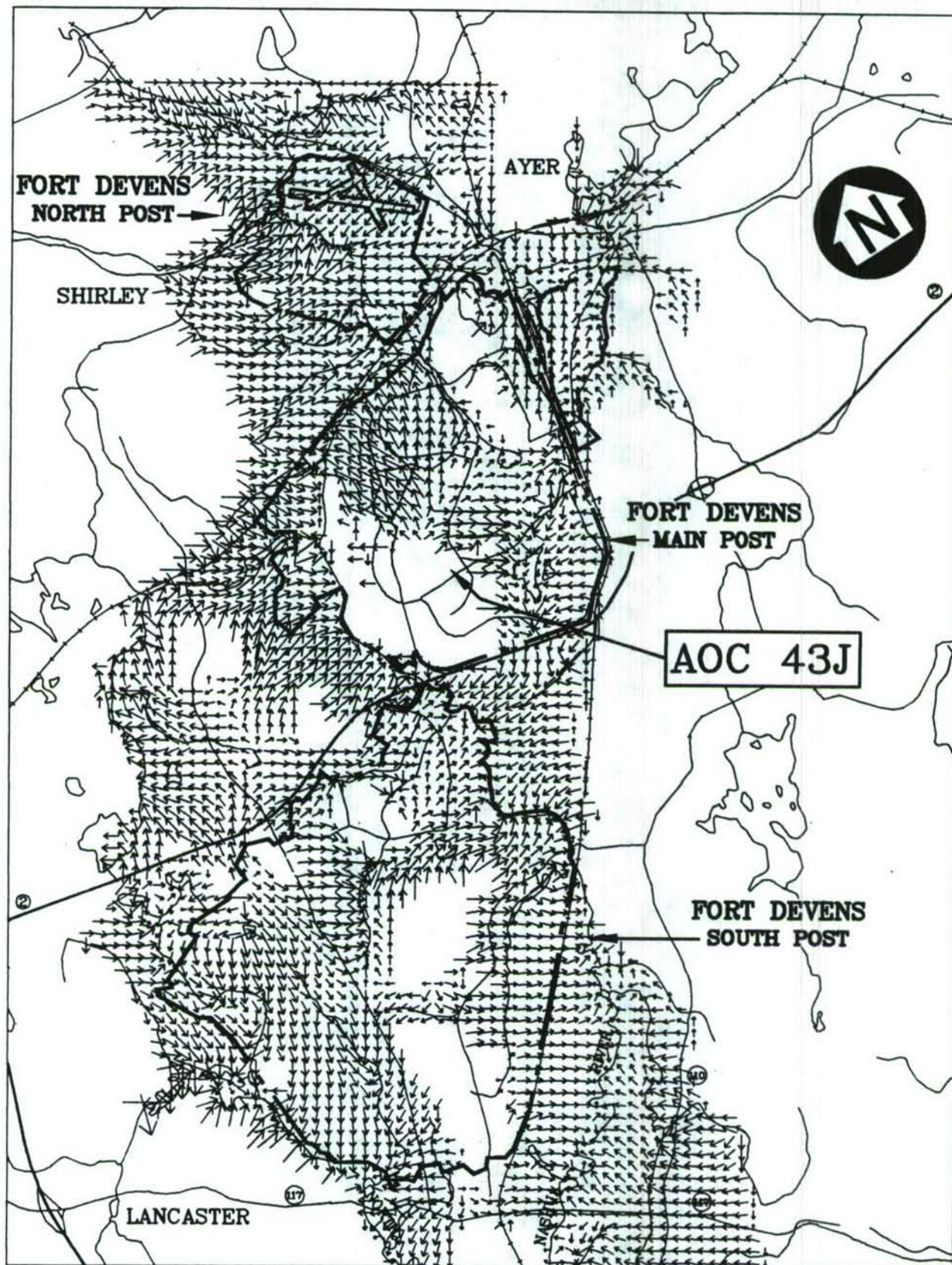






**FIGURE 2-5**  
**REGIONAL AQUIFER TRANSMISSIVITIES**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**  
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SOURCE:  
DRAFT FINAL GROUNDWATER FLOW MODEL AT FORT DEVENS, MA,  
ETA, INC. OCTOBER 30, 1992.

 GROUNDWATER FLOW VECTORS

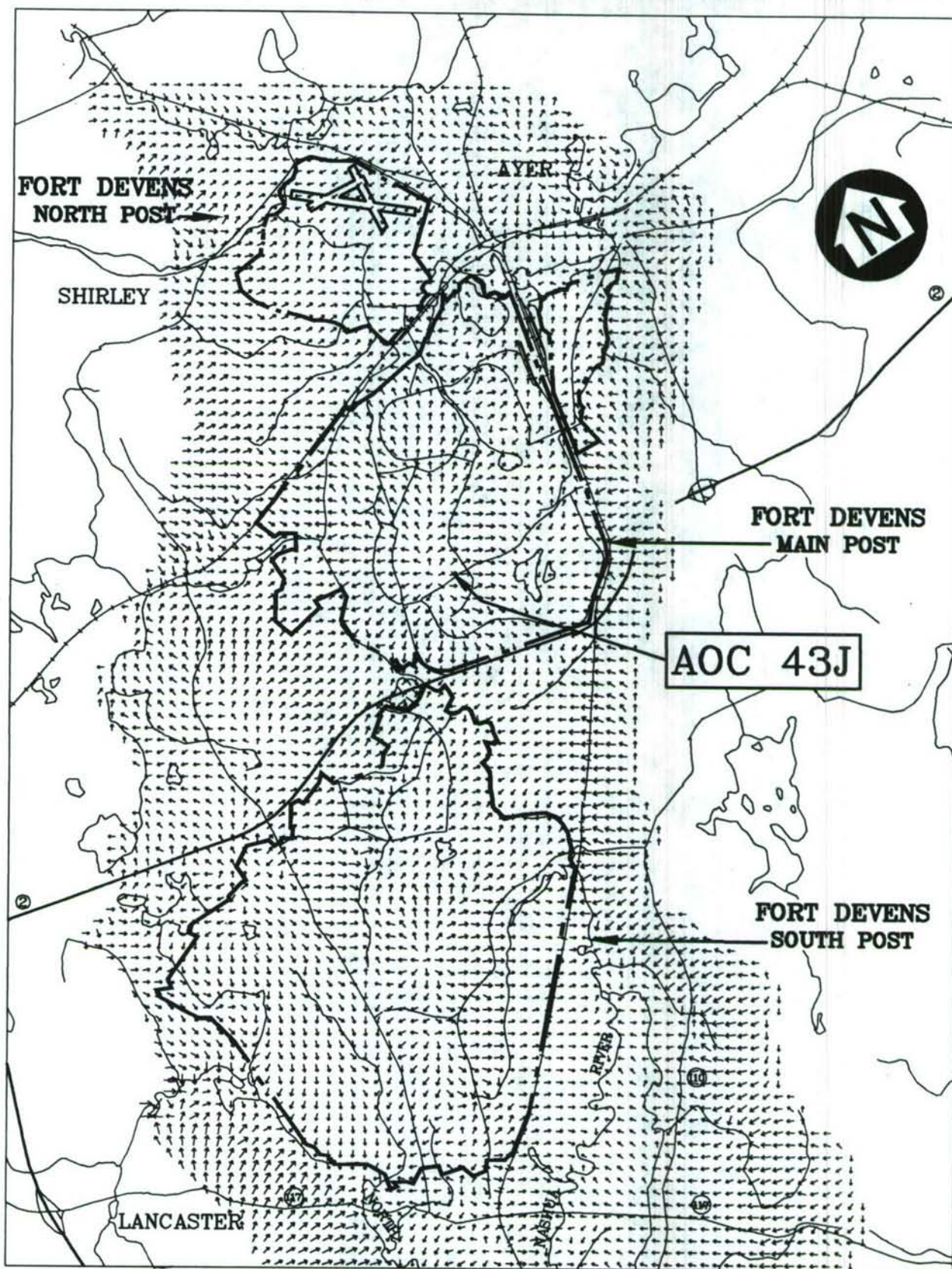
0 3000 6000 12000 FEET

SCALE: 1" = 6000'

FIGURE 2-6  
REGIONAL OVERBURDEN  
GROUNDWATER FLOW MAP  
AOC 43J-HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA  
ABB Environmental Services, Inc.







SOURCE:  
DRAFT FINAL GROUNDWATER FLOW MODEL AT FORT DEVENS, MA,  
ETA, INC. OCTOBER 30, 1992.

GROUNDWATER FLOW VECTORS

0 3000 6000 12000 FEET

SCALE: 1" = 6000'

FIGURE 2-7  
REGIONAL BEDROCK  
GROUNDWATER FLOW MAP  
AOC 43J-HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA  
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### 3.0 ANALYTICAL PROGRAM

Based on data obtained from previous investigations, an analytical program was established to identify contaminants that were potentially present due to historic activities at AOC 43J. Contaminants previously identified at AOC 43J are primarily associated with fuel and waste oil. The analytical program included field analysis as well as off-site laboratory analyses for a predetermined set of organic and inorganic analytes. The specific analytical methods used for these investigations are provided in Section 5.0 of this report and in the Revised Final Task Order Work Plan (ABB-ES, 1994b) and the Fort Devens Final POP (ABB-ES, 1993d). The following subsections describe the field and off-site analytical programs implemented for the 1992 through 1994 investigations completed by ABB-ES at AOC 43J.

#### 3.1 FIELD ANALYTICAL METHODS

Samples were analyzed in the field during each phase of investigation (SI, SSI, and RI) to provide real time chemical data. Soil and groundwater samples from AOC 43J were analyzed for volatile organic compounds (VOCs), and soil samples were analyzed for total petroleum hydrocarbons (TPHC). Data were primarily used to delineate the distribution of fuel-related contamination in soil and groundwater at and downgradient of AOC 43J. Target compounds and detection limits for field analysis compounds are outlined in Table 3-1. Samples submitted for field analysis included groundwater from screened auger borings, and soil taken from TerraProbe<sup>sm</sup> points and soil borings.

A Hewlett Packard 5890 Series II gas chromatograph (GC) in series with a Tekmar 3000 purge and trap concentrator was used to measure concentrations of VOCs in the different matrices (i.e., soil and groundwater). Several detectors were used in conjunction with the GC during the three field programs. Detectors included a flame ionization detector (FID), photoionization detector (PID), and electrolytic conductivity detector (ELCD). Target VOCs for AOC 43J measured on the FID and PID included benzene, toluene, ethylbenzene, m/p-xylene, and o-xylene (BTEX). During the 1994 RI, additional chlorinated organic compounds were measured on the ELCD including vinyl chloride, c-1,2-dichloroethene (1,2-

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DCE), t-1,2-DCE, trichloroethene (TCE), tetrachloroethene (PCE), 1,2-dichlorobenzene, and 1,1,2,2-tetrachloroethane (1,1,2,2-TCA). Only c- and t-1,2 DCE was identified as target compounds at AOC 43J. The ability to detect this compound provided additional chemical data about the site.

TPHC analyses for soils collected at AOC 43J during each field investigation were conducted using a Miran Fixed Filter Infrared Spectrophotometer (IR). This method is similar to USEPA Method 418.1. A soil microextraction sample preparation technique was developed for use in a field laboratory. The procedure followed for each field program is presented in the following subsections and the Fort Devens POP (ABB-ES, 1995).

### 3.1.1 Instrument Calibration

For analysis of samples for target compounds using a GC, an initial calibration was established. The initial calibration was accomplished through the analysis of three to five different concentrations of working standards. The response of the instrument to each standard was plotted versus the concentrations of standards to establish a calibration curve. The range of standards used to create the calibration curve was determined by the anticipated range of VOC contamination. A standard that contained all of the ELCD target compounds except vinyl chloride was used in concentrations of 2, 5, 10, 20 and 40 micrograms per liter ( $\mu\text{g/L}$ ) to create a calibration curve. The calibration curve for vinyl chloride was created from standard runs of 10, 20, and 40  $\mu\text{g/L}$ . A standard that contained all of the BTEX PID target compounds was used in concentrations of 2, 5, 10, 50, and 100  $\mu\text{g/L}$  to create a calibration curve. Once all points were established on the calibration curve, the linearity was measured using linear regression. The  $r^2$  value, which provided a measure of this linearity, was required to be a minimum of 0.990. No field samples were analyzed until this condition was satisfied.

Prior to analysis of samples, a continuing calibration check standard was analyzed each day to ensure that the response of the instrument had not changed from the initial calibration. The concentration of the check standard was at mid-level in the calibration curve. The initial calibration remained valid if concentrations obtained for the target analytes were no greater than 30 percent different from values obtained from the initial calibration. The percent difference was allowed

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to be greater than 30 percent for one compound. If continuing calibrations did not meet this criterion, a new initial calibration was created.

The IR, used for TPHC analysis, was calibrated using seven concentrations of standards prepared from chlorobenzene, hexadecane, and 2,2,4-trimethylpentane as specified in USEPA Method 418.1. Before standards were run, the IR was zeroed with the extraction solvent (freon). A series of standards were run at concentrations covering the working range of the instrument. The responses of each standard were recorded. The response factor was calculated for each concentration. The average response factor from the initial calibration was used to convert infrared readings to TPHC concentrations. TPHC instrument response and concentrations were recorded in the instrument logbook and manually entered into the database daily.

### **3.1.2 Sample Preparation and Analysis**

Sample preparation techniques for GC VOCs were adapted from protocols outlined in USEPA Method 5030 and Method 8010/8020 (USEPA, 1986). Soil samples were prepared for field analysis by the measurement of 5 grams into a soil sparger. For water samples, the amount used was 5 mL. The sample was loaded onto the purge and trap concentrator. Helium was purged through the sample to carry compounds onto a cold, compound-capturing silica/charcoal trap. The trap was heated to 235°C to liberate volatile compounds into a DB-624 capillary column that was installed in the GC. The capillary column served the purpose of separating out the various compounds. An FID detector was used during the 1992 and 1993 site investigations. For the 1994 RI field analytical program, PID and ELCD detectors were located in series at the end of the column. The amount of time spent in the capillary column (retention time) by each compound was determined by its molecular weight and the temperature program of the GC. A retention time window of  $\pm 3\%$  was used for the identification of target compounds.

TPHC analyses were completed for soil samples during investigations at AOC 43J conducted during 1992, 1993, and 1994. The method used for determination of TPHC was modeled after that specified for USEPA Method 418.1. Soils were prepared for this ABB-ES field TPHC analysis by weighing out 2 grams of the sample into a test tube. Roughly 2 grams of sodium sulfate was added to the test

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tube to remove water. After this step was completed, 10 mL of 1,1,2-trichloro-1,1,2-trifluoroethane (freon) was added as the solvent. The freon served to extract fuel compounds from the soil. The freon/soil mix was vortexed to ensure mixing. The freon was decanted off and poured into another test tube that contained silica gel. The silica gel was used to remove plant and animal protein oils. Plant and animal protein oils left in the freon extract could have produced false positive readings. The freon/silica gel mix was vortexed to ensure mixing. Freon was decanted off from the test tubes into a curvet for TPHC measurement in the IR.

### 3.1.3 Target Compound Concentrations Calculations

Target VOC concentrations were determined from comparisons of responses of compounds in samples versus responses from standards in the initial calibration curves described in Subsection 3.1.1. TPHC concentrations were obtained by comparison of sample extract responses to responses of various concentrations of standards. Soil and sediment compound concentrations were reported on a dry weight basis. The percent solid fraction of soil samples was determined by drying out the samples in an oven. The dry weight of the sample divided by the wet weight provided a solid fraction value. Solid fraction data was used to calculate final VOC and TPHC concentrations. Dilutions performed on both water and soil samples were also used to calculate final VOC concentrations. Dilution factors were calculated for any analysis where sample amounts were modified due to high concentrations of chemicals present in the samples. Samples for VOC analyses were prepared based on procedures outlined in USEPA Method 5030 (USEPA, 1986). Final sample results were calculated by dividing original unadjusted sample results by the fraction of solid and multiplying any results by the dilution factor.

### 3.1.4 Field Documentation Procedures

Instrument logbooks were completed for each instrument used during each field analytical programs. A log of all chromatography runs was recorded in these logbooks. A separate logbook was maintained for GC and IR results. The logbooks recorded the concentrations for all calibration standards used, instrument maintenance records, percent solid determination data, sample run number, sample identifier, date, standard preparation records, sample volume or

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weight, and any additional comments or observations of the field chemist. In addition, the results from each GC run were saved into a computerized data-base.

At the conclusion of field efforts for each investigation, raw data from the GC analyses and instrument logbooks were transferred for storage at ABB-ES' office. Raw data includes chromatograms, quantitation reports, and instrument and notebook records to document analyses.

### **3.1.5 Field Analytical Quality Control**

A QC program for the field analytical results was established prior to commencement of each investigation. Field analysis using an on-site laboratory was conducted during the 1992, 1993, and 1994 field investigations. Each program was developed to ensure that the data generated at the field laboratory were of sufficient quality to be considered satisfactory for their intended use. QC parameters for the 1994 RI field analytical program included initial and daily calibration check standard runs, an independent check standard evaluation, mid-level check standards after every ten samples, low-level and mid-level method blanks, cleaning blanks, matrix spikes and field or laboratory duplicates. The QC program that was implemented during the SI in 1992 and the 1993 SSI was identical to the RI field program except that matrix spike and duplicate samples were not analyzed, and continuing calibration check standards were only run once per day. QC objectives for the on-site laboratory analyses are outlined in the Fort Devens POP (ABB-ES, 1993d) and Appendix D. QC sample results for the on-site laboratory are discussed in Appendix D.

Instruments were calibrated using initial calibration procedures outlined in Subsection 3.1.1. Daily calibration checks were completed to ensure that the response of the detectors on the GC did not change significantly enough to compromise reported concentrations. If the reported concentration was greater than 30 percent different from the actual concentration for all but one of the target compounds, a new calibration curve was established.

Beginning in the 1994 RI, an independent check standard was prepared from neat standards of the VOC target compounds obtained from a different chemical supplier than those were used to prepare working standards. The purpose of completing analysis of this standard was to determine the analytical precision of

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the method and to confirm that there was good precision in the preparation of the standards. A mid-level concentration of this standard was analyzed and compared to the calibration curve established using the working standard. The concentrations of the target compounds from the independent check standard were required to be within thirty percent of the mid-point concentration established using the working standard. Results from the independent check standard analysis are contained in Appendix D.

Method blanks were analyzed daily to document that the analytical system was free of contamination. Samples were not run if there were any target compounds detected above the Practical Quantitation Limit (PQL) in the method blank. In addition to the low-level method blank, a mid-level method blank was run in instances where methanol extractions were necessary. One hundred microliters of methanol were added to deionized water and analyzed to ensure that it was free of contamination.

During VOC GC analyses, cleaning blanks were run at the beginning of each day to show that the analytical system was clean. They also were run after particularly heavily contaminated samples were run through the GC.

During the 1994 RI program, matrix spikes were analyzed to determine if the soil or water matrix had any influence in retarding or enhancing the concentrations of target compounds. A sample was first run to determine baseline values of the target compounds. A known concentration of a mix of the target compounds was added to a sample and analyzed as a regular sample. The reported concentrations were adjusted by subtracting the baseline concentration of a particular analyte which was measured in the sample before it was spiked. This result was then divided by the actual concentrations at which analytes were spiked and multiplied by 100 to calculate the percent recovery. Matrix spikes results for 1994 RI field analyses are presented in Appendix D.

For VOC analyses, a surrogate was added to every sample to determine if the matrix was having an effect on the recovery of the target compounds. The surrogate used for all field investigations was 4-bromofluorobenzene. This surrogate was used because it is chemically similar to the target compounds and responds well on the detectors selected for the field programs. Surrogate

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recoveries had to be from 30 percent to 170 percent to be considered acceptable. Samples for which the surrogate did not meet this criteria were reanalyzed.

Field duplicate samples were also analyzed to determine the precision of sampling and analytical techniques. Reported concentrations of target compounds for each sample and associated duplicate pair were compared by calculating the relative percent difference (RPD) of the results. RPDs were compared to criteria from USEPA Region 1 validation guidelines to evaluate the precision of measurements. Duplicate results for the 1994 RI are presented in Appendix M.

### 3.1.6 Method Detection Limits and Data Qualifiers

Method Detection Limits (MDLs) were established during the 1994 RI for both the ELCD and PID detector. MDLs were also established for the FID during the SSI completed in 1993. The MDL study was completed for all VOC target compounds to provide data to support the PQLs established for the various field programs. MDLs were calculated based on procedures published in Code of Federal Regulations (CFR) Appendix B Part 136, vol. 49, no. 209. The MDL study provides an estimation of the lower concentration limit of what the detectors were able to measure. The MDL is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. They were determined by running seven consecutive runs of a premixed standard at a concentration believed to be near the threshold of detection. The concentration used for all target compounds in the MDL study was 2 µg/L.

Once the seven low concentration runs of the standard were completed, the mean and standard deviation were calculated for the area counts reported by the instrument. These values were inserted into the equation below to determine the MDL.

$$MDL = \frac{\text{standard deviation of peak area} \times 3.14 \text{ (student } t \text{ number for 7 runs)}}{\text{mean peak area}}$$

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The MDLs obtained during the 1994 RI field analytical program are presented in Table 3-1.

MDLs were also established during the SSI completed in 1993 for benzene, toluene, ethylbenzene, m/p-xylene, and o-xylene. The MDLs obtained in 1993 using the FID detector ranged from 0.08 to 0.09  $\mu\text{g/L}$ .

PQLs were established to provide a margin of error from the MDL since the MDL identifies the threshold concentration of what the detector was capable of measuring. MDLs were conducted during the SSI and RI phases to provide a high level of data quality and dependability of field analytical results. PQLs for the 1992, 1993, and 1994 programs are outlined on Table 3-1. PQLs were used as reporting limits for field sample results during the 1994 RI. In the 1993 SSI, MDLs served as reporting limits.

In some instances, data qualifiers were used to address data quality issues associated with a particular sample. The following qualifiers were used during site and remedial investigations at Fort Devens:

- E - Denotes target compound concentrations that exceeded the highest standard of the calibration curve.
- U - Denotes sample concentrations that are less than PQLs or MDLs.

Results of the on-site sample analyses are presented in discussions of the nature and distribution of site contaminants presented in Section 7.0 of this report.

### 3.2 OFF-SITE LABORATORY ANALYTICAL PARAMETERS

Soil and groundwater samples collected from AOC 43J were analyzed at an off-site laboratory for chemical parameters on the Fort Devens Project Analyte List (PAL). Off-site laboratory analyses for PAL organics and inorganics were considered approximately equivalent to USEPA Level III quality data. The Fort Devens PAL and laboratory methods are presented in the Fort Devens POP (ABB-ES, 1993d) and Appendix K of this report.

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Laboratories performing the analytical work for all AOC 43J investigations have been required to implement the 1990 USATHAMA (now USAEC) QA Program (USATHAMA, 1990). All method performance demonstration, data management, and oversight for previous USATHAMA analytical procedures are currently performed by the USAEC.

The off-site laboratory contracted to implement the analytical program for all phases of investigation at AOC 43J was Environmental Science and Engineering (ESE). This laboratory was approved to complete analyses using USATHAMA and USEPA methods. These analyses were completed while implementing the 1990 USATHAMA QA Program. Specific performance demonstration and QC components of the 1990 USATHAMA QA Plan are detailed in Subsection 3.2.3 of this report.

The following subsection describes the procedures implemented to achieve the objectives of the QA program and any additional QC processes implemented during the SI, SSI and RI.

### **3.2.1 Off-Site Laboratory Certification**

In accordance with the 1990 USATHAMA QA Program, laboratories were required to demonstrate competency by performance demonstration of the PAL analytical methods conducted in association with field investigations. The USAEC requires that a laboratory demonstrate proficiency in performing USAEC methods for specific analytes. Analytical methods are based on USEPA procedures (USEPA, 1986; USEPA, 1983). Laboratories demonstrate proficiency by submitting data from runs of pre-certification calibration standards. Performance samples are then sent for analysis to the laboratory by the USAEC. The true concentrations of the analytes in the performance samples are unknown by the laboratory. The data obtained from the analyses of these samples are then sent to the USAEC to determine the laboratory precision and accuracy. Qualifications to perform USAEC methods are awarded to laboratories based on this performance. Certified Reporting Limits are also determined through this process. A method code associated with each USAEC analysis and laboratory is then assigned and reported with the results.

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For some methods such as alkalinity, total organic carbon (TOC), TPHC, and total suspended solids (TSS), there are no associated USAEC methods. The USAEC recognizes standard USEPA protocols or internal laboratory methods for these analyses. Laboratories are required to submit information on procedures for analyzing samples using these methods to the USAEC Chemistry Branch before they are implemented.

### 3.2.2 Laboratory Methods Quality Control

All field samples sent to ESE were organized into lots which were assigned a three digit code using letters of the alphabet. Each lot consisted of the maximum number of samples, including QC samples, that can be processed through the rate limiting step of the method during a single time period (not exceeding 24 hours). Associated with each lot were laboratory control samples. Control samples were spikes of high and low concentrations of specific analytes that help monitor ESE precision and accuracy. The recoveries of these spikes were plotted on control charts generated by the laboratory and submitted to the USAEC. Data generated during the performance demonstration process were used to calculate a mean of the recoveries. Control and warning limits were statistically generated by the USAEC Chemistry Branch to help measure laboratory data quality. Control charts are generated with each lot providing a continuous benchmark for trend evaluation of ESE's performance.

Method blanks were also analyzed at ESE to evaluate the potential for target analytes to be introduced during the processing and analysis of samples. One method blank was included with each analytical lot. Because analytical lots included samples from several areas, method blank results are presented and discussed by year of investigation for AOCs 43J in Appendix D. Only method blank data associated with samples from these AOCs were used for the QC report.

### 3.2.3 Data Reduction, Validation, and Reporting

Initial responsibility for accuracy and completeness of Fort Devens analytical data packages was with the contract laboratory. All data submissions to the USAEC first underwent a review process. This review included checks on the data quality that evaluated completeness of the laboratory data, accuracy of reporting limits,

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compliance with QC limits and holding times, and correlation of laboratory data to associated laboratory tests.

The following items were also validated by ESE before submission to the USAEC:

- chain of custody records;
- instrument printouts for agreement with handwritten results;
- calibration records to ensure a particular lot is associated with only one calibration;
- chromatograms and explanations for operator corrective actions (such as manual integrations);
- standard preparation and documentation of source standards;
- calculations on selected samples;
- notebooks and sheets of paper to ensure all pages were dated and initialed, and explanations of procedure changes;
- GC/MS library search of unknown compounds; and
- transfer files and records to ensure agreement with analysis results.

To document the data review and validation process, a data-review checklist was submitted as part of each data package.

#### **3.2.4 Data Reporting**

After review and validation by ESE, the dates were encoded for transmission into the USAEC's Installation Restoration Data Management Information System (IRDMIS) as Level 1 data. IRDMIS, a computerized data management system used by the USAEC, is described in detail in Subsection 3.3. Once the data were entered into the system, a group and records check was completed. Data were

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then transferred to USAEC's data management contractor. At the successful completion of the group and records check, the data were elevated to Level 2. Another group and records check was performed and the data were reviewed by the USAEC Chemistry Branch. When errors were identified, the data were returned to ESE for correction. Control charts were produced by ESE that plotted recoveries of high and low concentrations of laboratory control spikes of the target analytes. The control charts provided the USAEC with information about the accuracy of the analytical methods performed by ESE. Once data were reviewed by the USAEC Chemistry Branch, the determination was made on a lot-by-lot basis whether the data were acceptable. The data that were accepted were then elevated to Level 3 and made available to USAEC personnel and ABB-ES by modem to a main frame computer. Off-site results are presented in Section 7.0 and Appendix D.

### 3.2.5 Field Quality Control Samples

Field QC samples that were collected during various investigations conducted at AOC 43J included a field blank (source water), matrix spikes/matrix spike duplicates (MS/MSD), field duplicate samples, rinse blanks and trip blanks.

Before field investigations were initiated at AOC 43J, a sample of water was collected from the source which was used for sampling equipment decontamination. The water source used for each field investigation at AOC 43J was the South Post Water Point (Well D-1). For the purpose of laboratory QC, this was identified as the field blank (source water sample). The field blank data were sent to the USAEC Chemistry Branch where approval was granted for the use of this water in decontamination procedures. The information gained from the analysis of the field blank provided data on the quality of the USAEC-approved water used in the decontamination of the sampling equipment. Field blank data were also used to explain the presence of certain analytes or compounds in rinse blanks. Several field blanks were collected from the spring of 1992 to 1994. All field blank data are discussed with the 1992 QC data in Appendix D.

As specified in the Fort Devens POP (ABB-ES, 1993c), MS/MSDs were spiked and analyzed for PAL inorganics, explosives, and pesticides/polychlorinated biphenyls (PCBs). ABB-ES personnel made the determination of which samples

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were to be designated as MS/MSDs. This was noted on the COC forms submitted to ESE. Samples designated as MS/MSDs were spiked at the laboratory with specified analytes to determine matrix effects based on USAEC and USEPA method guidelines. MS/MSD data were also used to assess the accuracy of the analyses used. MS/MSD samples were collected at a rate of one set per 20 samples. During the Fort Devens field investigations, samples were collected from multiple study areas. After the twentieth sample was collected, a sample from any study area may have been designated for MS/MSD analysis. The MS/MSD samples were collected and analyzed at the specified frequency program-wide and not for specific SAs or AOCs. Therefore, assessments of MS/MSD data contained in Appendix D were not made specifically for AOC 43J but are discussed by year for AOCs 43J, 43G, and 41 collectively.

Field duplicate samples were also collected at a rate of one per 20 field samples. The purpose of duplicate sample analysis was to assess the sampling and off-site laboratory precision for particular methods. Since several AOCs were investigated simultaneously during some field efforts, designations for duplicate samples covered multiple SAs or AOCs. Duplicate data available for AOCs 43G, 43J, and 41 were assessed collectively by year of investigation. Duplicates submitted to ESE were analyzed for the same compounds as the corresponding field samples. Duplicate sample results are presented in Appendix D.

Rinsate blanks were collected and analyzed for PAL analytes. Rinsate blanks consisted of previously analyzed deionized water which was poured over sampling equipment. Analysis of this water provided information used to evaluate the potential for sample contamination during sample collection. The results were also used to assess decontamination of the sampling equipment. As specified in the Fort Devens POP (ABB-ES, 1993c), rinsate blanks were collected at a rate of one per 20 samples. Rinsate blank data associations were not made specifically for AOC 43J. Rinsate blanks that were shipped with any samples from AOCs 43G, 43J, or 41 were included in the data quality reports. Therefore, the discussions regarding rinsate blank contamination are relevant to all three AOCs rather than one specific AOC. Rinsate blank results were segregated by year of investigation and are presented in Appendix D.

For every shipment of VOC samples to ESE, there was an accompanying pair of trip blanks that traveled with the samples. The purpose of analyzing trip blanks

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was to determine if there was potential for VOC cross- contamination during the shipment and handling of samples. The trip blanks consisted of previously analyzed deionized water that was bottled at ESE. Trip blanks were shipped in sealed containers to the job site. As needed, trip blanks were then included with shipments of VOC field samples. Since many of these VOC field samples were taken from various AOCs, there is no association of trip blank data specifically to AOC 43J. Data were included for trip blanks sent with any samples from AOCs 43G, 43J, and 41. Trip blank assessments were separated by the year of investigation. All trip blank data are presented in Appendix D.

### 3.2.6 Off-Site Analytical Data Quality Evaluation

Laboratory data collected during the three investigations at Fort Devens were evaluated for possible laboratory or sampling-related contamination. This evaluation did not include validation by USEPA guidelines. Sample results reported and discussed in this report were not adjusted for reported analytes that were also detected at similar concentrations in blanks associated with that sample; action levels were not established, and the 10X rule was not applied to compounds considered by the USEPA to be common laboratory contaminants. Examples of these contaminants include the VOCs acetone, methylene chloride, 2-butanone, and the semivolatile organic compounds (SVOCs) bis (2-ethylhexyl)phthalate (BEHP) and di-n-butylphthalate. Likewise, action levels for other analytes using the 5X rule application were not established. Analytes which would have been below these action levels were not removed from the data as they would have been in the USEPA validation process.

General trends relating to blank and sample contamination were examined. Comparison of blank data with results from the entire data set are discussed as a data assessment. Assessments are made based on analyte detection in blanks, the frequency of the detection and the concentrations of these analytes. A summary of blank contamination was completed and is presented in Section 7.1.2 of this report.

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### **3.3 CHEMICAL DATA MANAGEMENT**

Chemical data from the AOC were managed by ABB-ES' Sample Tracking System and the USAEC's IRDMIS. These systems are described in the following sections.

#### **3.3.1 Sample Tracking System**

ABB-ES employed its computerized Sample Management System to track environmental samples from field collection to shipment to the off-site laboratory. ABB-ES also tracked the status of analyses and reporting by the off-site laboratory.

Each day, the field sampling teams carried computer-generated sample labels into the field that stated the sample control number, sample identification, size and type of container, sample preservation summary, analysis method code, and sample medium. The labels also provided space for sampling date, time, depth (if applicable), and the collector's initials to be added at the time of collection.

After collection in the field, the samples were stored on ice for transport back to ABB-ES' field office. Samples were temporarily stored in the ABB-ES field office refrigerator. They were checked-in on the field office computer, and the collector's initials and the sampling date and time were entered. The system would then indicate the sample status as "COLLECTION IN PROGRESS."

When the samples were prepared for shipment, they were "RELEASED" by the sample management system. Upon request, the system printed an Analysis Request Form (ARF) and a COC, which were signed and included with the samples in the shipment. The system would then indicate the sample status as "SENT TO LAB."

This system substantially reduced the time required for preparation of sample tracking documentation, and it provided an automated record of sample status.

After shipment of samples to the off-site laboratory, ABB-ES continued to use the sample tracking system to track and record the status of the samples, including the date analyzed (to determine actual holding times), the date a sample results

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transfer file was established by ESE, and the date the sample results transfer file was sent to IRDMIS (Section 3.3.2)

### 3.3.2 Installation Restoration Data Management Information System

IRDMIS is an integrated system for collection, validation, storage, retrieval, and presentation of data of the USAEC's Installation Restoration and Base Closure Program. It uses personal computers (PCs), a UNIX-based minicomputer, printers, plotters, and communications networks to link these devices.

For each sample lot, ABB-ES developed a "provisional" map file for the sample locations, which was entered into IRDMIS by Potomac Research, Inc. (PRI), USAEC's data management contractor.

Following analysis of the sample lot, ESE created chemical files using data codes provided by ABB-ES, and entered the analytical results (Level 1) on a PC in accordance with the User's Manual (PRI, 1993). For each sample lot, a hard copy was printed and was reviewed and checked by ESE's Laboratory Program Manager. ESE created a transfer file from accepted records which was sent to ABB-ES (Level 2). ABB-ES performed a group and record check and sent approved records in a chemical transfer file to PRI. PRI checked the data and, if accepted, entered it into the IRDMIS minicomputer (Level 3). Level 3 chemical data are the data used for evaluating site conditions and are the data used in this AOC 43J RI report and human health risk assessment.

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**TABLE 3-1**  
**1994 FIELD ANALYTICAL MDLs and PQLs FOR TARGET COMPOUNDS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Compound	Year	MDL (ug/L)	PQL (ug/L; ug/kg)
Vinyl Chloride	1994	2.07	4.0
t-1,2-Dichloroethene	1994	0.19	2.0
c-1,2-Dichloroethene	1994	0.15	2.0
TCE	1994	0.19	2.0
PCE	1994	0.19	2.0
1,1,2,2-TCA	1994	2.1	4.0
1,2-Dichlorobenzene	1994	0.23	2.0
Benzene	1992-1994	0.22	2.0
Toluene	1992-1994	0.19	2.0
Ethylbenzene	1992-1994	0.16	2.0
m/p-Xylene	1992-1994	0.33	2.0
o-Xylene	1992-1994	0.18	2.0





#### 4.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS IDENTIFICATION

CERCLA was enacted by Congress in 1980, establishing the Superfund program. The regulations implementing this program are found in 40 CFR Part 300, also known as the National Contingency Plan (NCP). CERCLA was amended in 1986 by SARA, which mandated that the level or standard of control specified in a remedial action be "at least that of any ARAR standard, requirement, criteria, or limitation under any federal environmental law, or any more stringent standard, requirement, criteria or limitation promulgated pursuant to a state environmental statute." SARA also established that the requirements of the NCP apply to federal facilities.

The purpose of the RI was to determine the nature and distribution of site-related soil and groundwater contamination at AOC 43J. In order to evaluate whether there is a potential threat to human health and the environment, preliminary ARARs are identified in this section and will then be compared to site-specific data. ARARs are federal and state human health and environmental requirements used to (1) evaluate the distribution of site impacts and the appropriate extent of site cleanup; (2) define and formulate remedial action alternatives; and (3) govern implementation and operation of the final remedy.

Identification and evaluation of ARARs is an iterative task, necessary throughout the remedial response process. Therefore, the preliminary lists of requirements identified for AOC 43J and their relevance may change as more information is obtained, as the preferred alternative is chosen, and as the design and approach to remediation becomes more refined.

Applicable Requirements - Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance that have jurisdiction at a site. An example of an applicable requirement is the use of the Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) drinking water standards for a

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site where hazardous substances have caused water in a public water supply distribution system to become contaminated.

Relevant and Appropriate Requirements - Relevant and appropriate requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a site, address problems or situations sufficiently similar to those encountered at the site that their use is well-suited to the particular site. For example, MCLs for drinking water would be relevant and appropriate requirements at a site where hazardous substances are found in or could enter drinking water classified as a current or future drinking water source. When a requirement is found to be relevant and appropriate, it is complied with to the same degree as if it were applicable.

To be Considered (TBC) Material. Non-promulgated advisories or guidance issued by the federal and state government are not legally binding and do not have the status of potential ARARs. However, in many circumstances, TBCs will be considered along with ARARs as part of the site risk assessment, and may be used in determining the level of cleanup for protection of human health or the environment.

ARARs that pertain to the remedial response can be classified into three categories: chemical-, location-, and action-specific. The following subsections provide an overview of these ARARs.

### 4.1 CHEMICAL-SPECIFIC ARARs

Because of their site-specific nature, the identification of ARARs requires an evaluation of the federal, state, and local environmental regulations with respect to chemicals of concern and site characteristics. Chemical-specific ARARs generally involve health- or risk-based numerical values or methodologies that establish site-specific acceptable chemical concentrations or amounts. These values are used to develop action levels or cleanup concentrations.

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#### **4.1.1 Groundwater**

Table 4-1 sets forth the federal chemical-specific ARARs and TBC information for groundwater. USEPA SDWA MCLs are legally applicable to contaminants found in public water systems that have at least 15 service connections or serve an average of at least 25 people daily at least 60 days per year. Even when not legally applicable, MCLs may be relevant and appropriate to groundwater remediation. Maximum contaminant level goals (MCLGs) are non-enforceable, health-based goals at which no known or anticipated adverse effects on health will occur and are considered TBCs. Table 4-1 also includes the current version of USEPA Region III risk-based concentrations (RBCs) which are commonly used as TBC information at CERCLA sites. The surface water criteria set forth in Table 4-1 are TBC information and will only be applicable if a discharge to surface water will be part of the groundwater remedial action.

Table 4-2 sets forth the state chemical-specific ARARs and TBC information for groundwater. The Commonwealth of Massachusetts has developed drinking water standard and guidelines, expressed in terms of maximum levels of contaminants allowed in drinking water. Groundwater data from AOC 43J will be applied to Massachusetts Maximum Contaminant Levels (MMCLs), Massachusetts Class I groundwater quality standards, and/or USEPA Region III RBCs for tap water.

#### **4.1.2 Soil**

Table 4-3 sets forth the soil screening levels (TBCs) from the current USEPA Region III RBC documents.

#### **4.1.3 Massachusetts Contingency Plan**

The NCP provides that CERCLA response actions must comply with environmental and public health laws and regulations to the extent they are substantive (i.e., pertain directly to actions or conditions in the environment), but do not need to comply with those that are administrative (i.e., mechanisms that facilitate the implementation of the substantive requirements).

The provisions of the MCP, 310 CMR 40.0000 (January 13, 1995) are mostly administrative in nature and, therefore do not have to be complied with in

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connection with the response action selected for AOC 43J. Further, the MCP contains a specific provision (310 CMR 40.0111) for deferring application of the MCP at CERCLA sites. As stated in the MCP, response actions at CERCLA sites are deemed adequately regulated for purposes of compliance with the MCP, provided the MADEP concurs in the CERCLA Record of Decision (ROD).

However, some provisions of the MCP contain substantive requirements that may be ARARs. Section 310 CMR 40.0940 sets forth three methods of risk characterization. Section 310 CMR 40.0942 provides that any of the three methods may be used, subject to certain specified limitations. MCP Method 1 establishes specific numerical standards for certain listed contaminants (see 310 CMR 40.0974.-0975). Since MCP Method 1 contains promulgated numerical standards, it may be an ARAR if this method is selected.

MCP Method 3 does not contain substantive numerical standards; rather it provides a risk characterization methodology to determine the appropriate cleanup level (see 310 CMR 40.0991.-0996). Because MCP Method 3 is a methodology and does not contain substantive standards, and because it defines protectiveness in a way which is inconsistent with the CERCLA NCP, Method 3 is not an ARAR which has to be met. Therefore, these standards of the MCP do not apply to the remedial response at AOC 43J.

### 4.2 LOCATION-SPECIFIC ARARs

Location-specific ARARs represent restrictions placed on the concentration of hazardous substances or the conduct of activities because of the location or characteristics of a site. These ARARs set restrictions relative to special locations such as wetlands, floodplains, sensitive ecosystems, as well as historic or archeological sites, and provide a basis for assessing existing site conditions. Table 4-4 lists location-specific federal and state requirements.

Some of the location-specific ARARs for areas such as wetlands and floodplains may or may not be applicable, or relevant and appropriate, depending on the remedial action selected because the regulations do not apply unless some activity is conducted in a certain defined area.

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### **4.3 ACTION-SPECIFIC ARARS**

Action-specific ARARs involve design, implementation, and performance requirements that are generally technology- or activity-based. Action-specific ARARs, unlike location- and chemical-specific ARARs, are usually technology- or activity-based limitations that direct how remedial actions are conducted. After remedial alternatives are developed, the evaluation of action-specific ARARs is one criterion for assessing the feasibility and effectiveness of compliance with proposed remedial alternatives. The applicability of this set of requirements is directly related to the particular remedial activities selected for the site.

Table 4-5 represents an overview of potential action-specific ARARs that may or may not ultimately be applicable to AOC 43J.

### **4.4 BACKGROUND CONCENTRATIONS**

As a means to evaluate concentrations of inorganic analytes detected in samples collected as part of each phase of investigation, background concentrations were calculated for the Fort Devens installation. Background concentration calculations were based on analytical data results gathered from soil and groundwater samples collected throughout the Fort Devens installation, selected as representative of background (non-contaminated) conditions. Although most of the calculations include assumptions on both the distribution of chemical concentrations and on the selection of representative samples that are not statistically rigorous, the results are considered representative of actual background concentrations at Fort Devens.

For soil, chemical data gathered from 20 soil samples collected by Ecology & Environment, Inc. (E&E) as part of their Group 1A and 1B investigation activities were used. The samples were collected from the major soil associations throughout Fort Devens specifically to establish background concentrations of inorganic analytes in soil. The background soil samples were collected from locations that were visually undisturbed, at least 50 feet from any road, and 300 feet from any known SA.

The calculations were performed on 22 of the 23 PAL inorganic analytes (no data was available for thallium). For analytes that were not detected in the majority of

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soil samples, the detection limit for that analyte was selected as the background concentration. Sample location, data ranges, mean values, details of calculations, and calculated background concentrations are summarized in Appendix L.

For groundwater, ABB-ES selected 10 representative groundwater samples collected from the Round One groundwater sampling events, completed in 1992, for Groups 2, 3, 5, 6 and 7 for the purpose of calculating background inorganic analyte concentrations in groundwater. Representative groundwater samples were selected from specific monitoring wells located upgradient of a SA, exhibiting low TSS and/or low aluminum concentrations. Aware that elevated TSS concentrations artificially elevate inorganic analyte concentrations, ABB-ES selected samples that exhibited TSS concentrations on the same order of magnitude as the South Post Water Point (Well D-1). Because a close correlation between TSS concentrations and aluminum concentrations was observed in all the groundwater samples analyzed, the aluminum concentration was used as an alternate selection criterion in the absence of TSS data. The concentration values detected in the ten samples were calculated using the same assumptions on outliers and detection limits applied to the soils background concentration calculations. The statistical analysis calculations for groundwater inorganics, and the resulting background concentrations, data ranges, mean values, and details of the calculations are also provided in Appendix L.

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**TABLE 4-1**  
**FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER**  
**AOC 43J - HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Federal Standards and Guidance							
Analyte	Safe Drinking Water Act (SDWA) <sup>(a)</sup>		Clean Water Act (CWA)			TBC Region III Tap Water (µg/L)	
			Ambient Water Quality Criteria (AWQC) <sup>(b)</sup>				
			For Protection of Human Health		For Protection of Aquatic Life		
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)		
Volatile Organics							
acetone	-	-	-	-	-/-	-	3,700N
benzene	5	zero	0.66	40	5,300/- <sup>2</sup>		0.36C
carbon tetrachloride	5	zero	0.4	6.94	35,200/- <sup>2</sup>		0.16C
chloroform (THM)	100/80 <sup>3</sup>	zero	0.19	15.7	28,900/1,240 <sup>2</sup>		0.15C
ethylbenzene	700	700	1,400	3,280	32,000/- <sup>2</sup>		1,300N
styrene	100	100	-	-	-/-		1,600N
1,1,2,2-tetrachloroethane	-	-	0.17	10.7	-/2,400 <sup>2</sup>		0.052C
tetrachloroethylene	5	zero	0.8	8.85	5,280/840 <sup>2</sup>		1.10C
toluene	1,000	1,000	14,300	424,000	17,500/- <sup>2</sup>		750N
1,1,1-trichloroethane	200	200	18,400	1,030,000	-/-		1,300N
trichloroethylene	5	zero	2.7	80.7	45,000/21,900 <sup>2</sup>		1.6C
trichlorofluoromethane	-	-	-	-	-/-		1,300N
xlenes (total)	10,000	10,000	-	-	-/-		12,000N





TABLE 4-1  
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
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Federal Standards and Guidance						
Analyte	Safe Drinking Water Act (SDWA) <sup>(a)</sup>		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) <sup>(b)</sup>			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)		
	Semivolatile Organics					
acenaphthene	-	-	-	-	-/-	2,200N
anthracene	-	-	-	-	-/-	11,000N
bis(2-ethylhexyl)phthalate	6	zero	-	-	-/-	4.80C
benzo(a)anthracene	-	-	-	-	-/-	0.0092C
benzo(a)pyrene	2	zero	-	-	-/-	0.092C
benzo(b)fluoranthene	-	-	-	-	-/-	0.092C
benzo(g,h,i)perylene	-	-	-	-	-/-	-
benzo(k)fluoranthene	-	-	-	-	-/-	0.92C
benzyl alcohol	-	-	-	-	-	11,000N
carbazole	-	-	-	-	-/-	3.4C
chrysene	-	-	-	-	-/-	9.2C
dibenzofuran	-	-	-	-	-/-	150N
di-n-butyl phthalate	-	-	-	-	-	3,700N





TABLE 4-1  
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Federal Standards and Guidance						
Analyte	Safe Drinking Water Act (SDWA) <sup>(a)</sup>		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) <sup>(b)</sup>			TBC Region III Tap Water (µg/L)
			For Protection of Human Health		For Protection of Aquatic Life	
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
fluoranthene	-	-	-	-	-/-	1,500N
fluorene	-	-	-	-	-/-	1,500N
indeno(1,2,3-c,d)pyrene	-	-	-	-	-/-	0.092C
2-methylnaphthalene	-	-	-	-	-/-	-
naphthalene	-	-	-	-	2,300/620 <sup>2</sup>	1,500N
n-nitrosodiphenylamine	-	-	4.9	16.1	-/-	14C
phenanthrene	-	-	-	-	30/6.3 <sup>5</sup>	-
pyrene	-	-	-	-	-/-	1,100N
Inorganics						
aluminum	-	50 to 200 <sup>8</sup>			-/-	37,000N
antimony	6	6 <sup>5</sup>	146	45,000	88/30 <sup>5</sup>	15N
arsenic	50 <sup>1</sup>	-	0.0022	0.0175	360/190 <sup>2,7</sup>	11N/0.038C
barium	2,000	2,000	1,000		-/-	2,600
beryllium	4 <sup>4</sup>	4	0.0037	0.0641	130/5.3 <sup>2</sup>	0.016C





TABLE 4-1  
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER  
AOC 43J - HISTORIC GAS STATION J

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Analyte	Federal Standards and Guidance					
	Safe Drinking Water Act (SDWA) <sup>(a)</sup>	Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) <sup>(b)</sup>			TBC Region III Tap Water (µg/L)	
		For Protection of Human Health		For Protection of Aquatic Life		
		ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)		ARAR Fish Consumption Only (µg/L)
cadmium	5	5	10	-	3.9/1.1 <sup>4</sup>	18N
calcium	-	-	-	-	-/-	-
chromium (total)	100	100	-	-	1,700/210 <sup>4,9</sup>	180
cobalt	-	-	-	-	-/-	2,220
copper	TT <sup>10</sup>	1,300	-	-	18/12 <sup>4</sup>	1,400N
iron	-	300 <sup>8</sup>	300	-	-/1,000	-
lead	TT <sup>11</sup>	zero	50	-	83/3.2 <sup>4</sup>	-
magnesium	-	-	-	-	-/-	-
manganese	-	50 <sup>8</sup>	50	100	-/-	180N
mercury	2	2	0.144	0.146	2.4/0.012	11N
nickel	100 <sup>5</sup>	100 <sup>5</sup>	13.4	100	1,400/160 <sup>4</sup>	730N
potassium	-	-	-	-	-/-	-
selenium	50	50	10	-	20/5	180N
silver	-	100 <sup>8</sup>	50	-	4.1/0.12 <sup>4,6</sup>	180N





TABLE 4-1  
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER  
AOC 43J - HISTORIC GAS STATION J

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Analyte	Safe Drinking Water Act (SDWA) <sup>(a)</sup>		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) <sup>(b)</sup>			TBC Region III Tap Water (µg/L)	
			For Protection of Human Health		For Protection of Aquatic Life		
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)			ARAR Fresh Water Acute/Chronic (µg/L)
	sodium	-		-	-		-/-
vanadium	-					260N	
zinc	-	5,000 <sup>g</sup>	-	-	12/110 <sup>4</sup>	11,000N	
Pesticide/PCBs							
DDT	-	-	.000024	.000024	1.1/0.001	0.2C	
DDD	-	-	-	-	-/-	0.28C	
DDE	-	-	-	-	1,050/- <sup>2</sup>	0.2C	
endrin	2	2	1.0	-	0.18/.0023	11N	
alpha chlordane	2 <sup>13</sup>	zero <sup>13</sup>	0.00046 <sup>13</sup>	0.00048 <sup>13</sup>	2.4/0.0043 <sup>13</sup>	0.052 <sup>13</sup>	
gamma chlordane	2 <sup>13</sup>	zero <sup>13</sup>	0.00046 <sup>13</sup>	0.00048 <sup>13</sup>	2.4/0.0043 <sup>13</sup>	0.052C <sup>13</sup>	
heptachlor	0.4	zero	0.00028	0.00029	0.52/.0038	0.0023C	
PCB 1248	0.5 <sup>14</sup>	zero <sup>14</sup>	0.000079 <sup>14</sup>	0.000079 <sup>14</sup>	2.0/0.014 <sup>14</sup>	0.0087C	
PCB 1254	0.5 <sup>14</sup>	zero <sup>14</sup>	0.000079 <sup>14</sup>	0.000079 <sup>14</sup>	2.0/0.014 <sup>14</sup>	0.73N	
PCB 1260	0.5 <sup>14</sup>	zero <sup>14</sup>	0.000079 <sup>14</sup>	0.000079 <sup>14</sup>	2.0/0.014 <sup>14</sup>	0.0087C <sup>14</sup>	





TABLE 4-1  
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER  
AOC 43J - HISTORIC GAS STATION J

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Federal Standards and Guidance						
Analyte	Safe Drinking Water Act (SDWA) <sup>(a)</sup>		Clean Water Act (CWA)			TBC Region III Tap Water (µg/L)
			Ambient Water Quality Criteria (AWQC) <sup>(b)</sup>			
	For Protection of Human Health		For Protection of Aquatic Life			
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)	ARAR Fresh Water Acute/Chronic (µg/L)	
Explosives						
cycloetramethylenetetranitramine (HMX)	-	-	-	-	-	-
cyclonite (RDX)	-	-	-	-	-	-
2,4-dinitrotoluene	-	-	-	-	-	73N
2,6-dinitrotoluene	-	-	-	-	-	37N
nitroglycerine	-	-	-	-	-	-
2,4,6-trinitrotoluene	-	-	-	-	-	2.2C
Cations/Anions						
chloride		250,000 <sup>8</sup>	-	-	860K/230K	-
phosphate	-	-	-	-	-/-	-
sulfate	-	500,000 <sup>15</sup> /250,000 <sup>8</sup>	-	-	-/-	-
alkalinity	-	-	-	-	-/20,000	-





TABLE 4-1  
FEDERAL ARARS AND TBC GUIDANCE - GROUNDWATER AND SURFACE WATER  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Federal Standards and Guidance						
Analyte	Safe Drinking Water Act (SDWA) <sup>(a)</sup>		Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) <sup>(b)</sup>		TBC Region III Tap Water (µg/L)	
			For Protection of Human Health	For Protection of Aquatic Life		
	ARAR Drinking Water MCL (µg/L)	TBC Drinking Water MCLG (µg/L)	ARAR Water and Fish Consumption (µg/l)	ARAR Fish Consumption Only (µg/L)		ARAR Fresh Water Acute/Chronic (µg/L)
Other						
nitrate/nitrite as N	10,000/1,000 <sup>12</sup>	-	10,000/-			58,000N/3,100N
TPH	-	-				-

## Notes:

(a) USEPA, "Drinking Water Standards and Health Advisories", Office of Water, Washington, D.C.; May 1995.  
(b) USEPA, "Water Quality Criteria Summary", Office of Science and Technology, Health and Ecological Criteria Division, Washington, D.C.; May 1, 1991; criteria shown for carcinogens present a one-in-a-million incremental risk.

- CWA = Clean Water Act  
MCL = Maximum Contaminant Level  
MCLG = Maximum Contaminant Level Goal  
1 MCL for arsenic currently under review.  
2 Insufficient data to develop criteria. Value presented is the Lowest Observed Effect Level (LOEL).  
3 1994 Proposed rule for Disinfectants and Disinfection By-Products: Total for all THMs combined would not exceed the 80  $\mu\text{g/L}$  level.  
4 Hardness dependent criteria (100 mg/L  $\text{CaCO}_3$  used).  
5 Standard is being remanded.  
6 Proposed level, freshwater acute - 0.92  $\mu\text{g/L}$ .  
7 Values presented are for trivalent species.  
8 Non-enforceable secondary regulation based on aesthetics (e.g., color, odor, taste).  
9 Values presented are for hexavalent chromium species.  
10 Treatment technique action level 1,300  $\mu\text{g/L}$ .  
11 Treatment technique action level 15  $\mu\text{g/l}$ ; concentration measured at tap.  
12 Nitrate or nitrite as nitrogen; standard total nitrate and nitrite is 10,000  $\mu\text{g/l}$ .  
13 Values reported for chlordane (CAS #57-74-9)  
14 Values reported for total PCBs (CAS #1336-36-3)  
15 Proposed criteria.
- TT = Treatment technique required.  
 $\mu\text{g/L}$  = micrograms per liter  
N = No federal or state guidance criteria or standards exist.  
C = Noncarcinogenic effects representing an HQ of 1.0.  
C = Carcinogenic effects representing a cancer risk of  $10^{-6}$ .





**TABLE 4-2**  
**STATE ARARS AND TBC GUIDANCE - GROUNDWATER**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER <sup>(a)</sup> (μG/L)	CLASS I GROUNDWATER <sup>(b)</sup> (μG/L)
<b>Volatile Organics</b>		
acetone	3000 <sup>2</sup>	-
benzene	5	-
carbon tetrachloride	5	-
chloroform	5 <sup>2</sup>	100 <sup>3</sup>
ethylbenzene	700	-
styrene	100	-
1,1,2,2-tetrachloroethane	-	-
tetrachloroethylene	5	-
toluene	1000	-
1,1,1-trichloroethane	200	-
trichloroethylene	5	-
trichlorofluoromethane	-	-
xylene (total)	10,000	-
<b>Semivolatile Organics</b>		
acenaphthylene	-	-
anthracene	-	-
bis(2-ethylhexyl)phthalate	6	-
benzo(a)anthracene	-	-
benzo(a)pyrene	0.2	-
benzo(b)fluoranthene	-	-
benzo(g,h,i)perylene	-	-
benzo(k)fluoranthene	-	-
benzyl alcohol	-	-
carbazole	-	-
chrysene	-	-
dibenzofuran	-	-
di-n-butyl phthalate	-	-
fluoranthene	-	-
fluorene	-	-
indeno(1,2,3-c,d)pyrene	-	-
2-methylnaphthalene	-	-





TABLE 4-2  
STATE ARARS AND TBC GUIDANCE - GROUNDWATER  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER <sup>(A)</sup> (μG/L)	CLASS I GROUNDWATER <sup>(B)</sup> (μG/L)
naphthalene	-	-
n-nitrosodiphenylamine	-	-
phenanthrene	-	-
pyrene	-	-
<b>Inorganics</b>		
aluminum	50 to 200 <sup>(10)</sup>	-
antimony	6	-
arsenic	50	50
barium	2,000	1,000
beryllium	4	-
cadmium	5	10
calcium	-	-
chromium (total)	100	50
cobalt	-	-
copper	1,300	1,000
iron	300 <sup>10</sup>	300
lead	15	50
magnesium	-	-
manganese	50 <sup>(10)</sup>	50
mercury	2	2
nickel	100	-
potassium	-	-
selenium	50 <sup>10</sup>	10
silver	100 <sup>10</sup>	50
sodium	20,000 <sup>2</sup>	-
vanadium	-	-
zinc	5,000 <sup>10</sup>	5,000
<b>Pesticides/PCBs</b>		
DDT	-	-
DDD	-	-
DDE	-	-
endrin	2 <sup>8</sup>	0.2





**TABLE 4-2**  
**STATE ARARS AND TBC GUIDANCE - GROUNDWATER**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

ANALYTE	MASSACHUSETTS STANDARDS AND GUIDANCE	
	MMCL/ORSG DRINKING WATER <sup>(a)</sup> (µG/L)	CLASS I GROUNDWATER <sup>(b)</sup> (µG/L)
alpha chlordane	2 <sup>8</sup>	-
gamma chlordane	2 <sup>8</sup>	-
heptachlor	0.4	-
PCB 1248	0.5 <sup>9</sup>	-
PCB 1254	0.5 <sup>9</sup>	-
PCB 1260	0.5 <sup>9</sup>	-
<b>Explosives</b>		
cyclotetramethylenetetranitramine (HMX)	-	-
cyclonite (RDX)	-	-
2,4-dinitrotoluene	-	-
2,6-dinitrotoluene	-	-
nitroglycerine	-	-
2,4,6-trinitrotoluene	-	-
<b>Cations/Anions</b>		
chloride	250,000 <sup>10</sup>	-
phosphate	-	-
sulfate	250,000 <sup>10</sup>	250,000
alkalinity	-	-
<b>Other</b>		
nitrate/nitrite (total)	10,000	10,000 <sup>8</sup>
TPH	-	-

**Notes:**

- (a) MADEP - Office of Research and Standards; Massachusetts Drinking Water Standards and Guidelines, (310 CMR 22.00) Massachusetts MCLs; Autumn 1992.
- (b) MADEP - Division of Water Pollution Control; Massachusetts Surface Water Quality Standards, (314 CMR 6.06) Minimum GW Quality Criteria - Class I; promulgated December 31, 1986.
- (c) MADEP - Division of Water Pollution Control; Massachusetts Surface Water Quality Standards, (314 CMR 4.05[b]) Class B criteria; promulgated July 20, 1990.
- (d) MADEP; Massachusetts Drinking Water Standards; (310 CMR 22.05[8]) Maximum Microbiological Contaminant Levels; promulgated November 20, 1992.

DWS = Drinking Water Standards  
MCLG = Maximum Contaminant Level Goal  
MMCL = Massachusetts Maximum Contaminant Level  
ORSG = Office of Research and Standards Guideline (Massachusetts)  
µg/l = micrograms per liter  
- = Standard not established.

- (1) MMCL established for 1,4-dichlorobenzene isomer (more stringent than for 1,2- isomer). Reported values are totals (isomers not distinguished.)
- (2) Value is an Office of Research and Standards guideline.
- (3) Standard indicated is concentration of total trihalomethanes (i.e., the sum of concentrations of chloroform, bromodichloromethane, dibromochloromethane, and bromoform).





- (4) Defers to EPA DWS; see federal MCLs/MCLGs.
- (5) Mean value per any set of samples.
- (6) Numerical standard does not exist. MMCL is based on presence or absence of coliform.
- (7) Nitrate as nitrogen.
- (8) Value reported for chlordane; CAS No. 57749.
- (9) Value reported for PCBs; CAS No. 1336363.
- (10) SMCL = Secondary Maximum Contaminant Levels.





TABLE 4-3  
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT  
AOC 43J - HISTORIC GAS STATION J  
  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT <sup>a</sup> EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC <sup>c</sup> (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL <sup>a</sup> (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL <sup>a</sup> (MG/KG)		
Volatile Organics				
acetone	7,800N	200,000N	-	-
benzene	22C	200C	-	-
carbon tetrachloride	4.9C	44C	-	-
chloroform	100C	940C	-	-
ethylbenzene	7,800N	200,000N	-	-
styrene	16,000N	410,000N	-	-
tetrachloroethylene	12C	110C	-	-
toluene	16,000N	410,000N	-	-
1,1,1-trichloroethane	7,000N	180,000N	-	-
1,1,2,2-tetrachloroethane	3.2C	29C	-	-
trichloroethylene	58C	520C	-	-
trichlorofluoromethane	23,000N	610,000N	-	-
xylenes (total)	160,000N	1E+06N	-	-
Semivolatile Organics				
acenaphthene	-	-	-	-
anthracene	23,000N	610,000N	-	-
bis(2-ethylhexyl)phthalate	46C	410C	-	-





TABLE 4-3  
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT* EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC <sup>c</sup> (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL* (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL* (MG/KG)		
benzo(a)anthracene	0.88C	7.8C	-	1,317
benzo(a)pyrene	0.088C	0.78C	0.4	1,063
benzo(b)fluoranthene	0.88C	7.8C	-	-
benzo(g,h,i)perylene	-	-	-	-
benzo(k)fluoranthene	8.8C	78C	-	-
benzyl alcohol	23,000N	610,000N	-	-
carbazole	32C	290C	-	-
chrysene	88C	780C	0.4	-
dibenzofuran	310N	8200N	-	-
di-n-butyl phthalate	7,800N	200,000N	-	-
fluoranthene	3,100N	82,000N	0.6	1,883
fluorene	3,100N	82,000N	0.035	-
indeno(1,2,3-c,d)pyrene	0.88C	7.8C	-	-
2-methylnaphthalene	-	-	-	0.065
naphthalene	3,100N	82,000N	0.34	-
n-nitrosodiphenylamine	130C	1200C	-	-
phenanthrene	-	-	0.225	139
pyrene	2,300N	61,000N	0.35	1,311





TABLE 4-3  
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT* EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC <sup>c</sup> (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL <sup>a</sup> (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL <sup>a</sup> (MG/KG)		
total PAHs	-	-	4.0	-
<b>Inorganics</b>				
aluminum	78,000N	1E+06N	-	-
antimony	31N	820N	0.002	-
arsenic	0.37C/23N	3.3C/610N	0.033	-
barium	5,500N	140,000N	-	-
beryllium	0.15C	1.3C	-	-
cadmium	39N	1,000N	0.005	-
calcium	-	-	-	-
chromium	390N <sup>i</sup>	10,000N <sup>i</sup>	0.080	-
cobalt	4,700N	120,000N	-	-
copper	2,900N	76,000N	0.070	-
iron	-	-	-	-
lead	-	-	0.035	-
magnesium	-	-	-	-
manganese	390N	10,000N	-	-
mercury	23N	610N	0.00015	-
nickel	1,600N	41,000N	0.030	-
potassium	-	-	-	-





TABLE 4-3  
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT <sup>a</sup> EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC <sup>c</sup> (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL <sup>a</sup> (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL <sup>a</sup> (MG/KG)		
selenium	390N	10,000N	-	-
silver	390N	10,000N	0.001	-
sodium	-	-	-	-
vanadium	550N	14,000N	-	-
zinc	23,000N	610,000N	0.120	-
<b>Pesticides/PCBs</b>				
DDT	1.9C	17C	0.001	0.828
DDD	2.7C	24C	0.002	-
DDE	1.9C	17C	0.002	-
endrin	23N	610N	0.00002	.0332
alpha chlordane	0.49C <sup>3</sup>	4.4C <sup>3</sup>	0.0005 <sup>3</sup>	-
gamma chlordane	0.49C <sup>3</sup>	4.4C <sup>3</sup>	.0005 <sup>3</sup>	-
heptachlor	0.14C	1.3C	-	0.110
PCB 1248	0.083C <sup>4</sup>	0.74C <sup>4</sup>	0.05 <sup>4</sup>	-
PCB 1254	1.6N	41N	0.05 <sup>4</sup>	19.5
PCB 1260	0.083C <sup>4</sup>	0.74C <sup>4</sup>	0.05 <sup>4</sup>	-
<b>Explosives</b>				
cycloctramethylenetetranitramine (HMX)	-	-	-	-





TABLE 4-3  
ARARS AND TBC GUIDANCE - SOIL AND SEDIMENT  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE	SOIL INGESTION		TBC NOAA SEDIMENT <sup>a</sup> EFFECTS RANGE - LOW (MG/KG)	TBC USEPA SQC <sup>c</sup> (MG/KG ORGANIC CARBON)
	TBC REGION III/ RESIDENTIAL <sup>a</sup> (MG/KG)	TBC REGION III/ COMMERCIAL/ INDUSTRIAL <sup>a</sup> (MG/KG)		
cyclonite (RDX)	-	-	-	-
2,6-dinitrotoluene	78N	2000N	-	-
2,4,6-trinitrotoluene	21C	190C	-	-
nitroglycerine	-	-	-	-
Other				
nitrate/nitrite	130,000N/7,800N	1E+06N/200,000N	-	-
TPH	-	-	-	-

Notes:

- (1) Chromium IV values.
- (2) Dry weight.
- (3) Values reported for chlordane (CAS # 57-74-9).
- (4) Values reported for total polychlorinated biphenyls (CAS # 1336-36-3).
- (a) U.S. Environmental Protection Agency (USEPA) Region III, January 1995. Memorandum from Roy L. Smith to RBC (Risk-Based Concentration) Table Mailing List, Subject: Risk-Based Concentration Table.
- (b) National Oceanic and Atmospheric Administration (NOAA), March 1990. "The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National States and Trends Program"; NOAA Technical Memorandum NOS OMA52. (Edward R. Long and Lee G. Morgan, authors)
- (c) USEPA, May 1988. "Interim Sediment Quality Criteria Values for Nonpolar Hydrophobic Organic Contaminants".
- (d) USEPA OSWER Directive 193554-02.

mg/kg = milligrams per kilogram  
 NOAA = National Oceanic and Atmospheric Administration  
 N = Non-carcinogenic effects representing an HQ of 1.0.  
 1E+06 = 1,000,000  
 SQC = Sediment Quality Criteria  
 - = No federal or state guidance criteria or standards exist.  
 C = Carcinogenic effects representing a cancer risk of 10<sup>-6</sup>.





**TABLE 4-4**  
**POTENTIAL LOCATION-SPECIFIC ARARS AT FORT DEVENS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Statutory, Regulatory Basis	Citation	Description
Resource Conservation and Recovery Act	40 CFR Sec. 264.18	Prohibits or restricts siting of hazardous waste management units in certain sensitive areas (100-year floodplain, active seismic area, wetlands).
Migratory Bird Treaty Act of 1972	16 USC Sec. 703-712 50 CFR Parts 10, 20, 21	If migratory birds are present, provides protection of almost all species of native birds in the U.S. from unregulated activities. Unregulated activities can include poisoning at hazardous waste sites.
Fish and Wildlife Conservation Act of 1980	16 USC Sec. 2901 50 CFR Part 83	Requires the submittal of conservation plans outlining provisions to conserve non-game fish and wildlife. Approved conservation plans are enforced by state agencies.
Federal Land Policy and Management Act	13 USC Sec. 1700 et seq.	Establishes requirements concerning utilization of public lands, particularly rights-of-way regulation, land use planning and land acquisition and appropriation of waters on public lands.
Fish and Wildlife Improvement Act	16 USC Sec. 661-666c	Provides for development, protection, rearing, and stocking of all species of wildlife, wildlife resources, and their habitat.
Endangered Species Act	16 USC 1531 et seq. 50 CFR Part 200 50 CFR Part 402	Provides for protection and conservation of various species of fish, wildlife, and plants.
Clean Water Act, Section 404	33 USC 1251 et seq. Sec. 404 40 CFR Part 230	Prohibits discharge of dredged or fill material into wetlands without a permit.





**TABLE 4-4**  
**POTENTIAL LOCATION-SPECIFIC ARARS AT FORT DEVENS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Statutory, Regulatory Basis	Citation	Description
Fish and Wildlife Improvement Act	33 CFR 320-330	Provides for management of dredged material; establish requirements for structures affecting navigable waterways; and provides for certain permitting requirements.
Archaeological and Historic Preservation Act	16 USC Sec. 469 40 CFR 6.301(c)	Establishes procedures for preservation of historical and archaeological resources when terrain is altered as a result of a federal or federally licensed construction activity.
National Historic Preservation Act	16 USC Sec. 470 40 CFR Sec. 6.301(b) 36 CFR Part 800	Provides for the protection of historic places.
Historic Sites, Buildings, and Antiquities Act	16 USC Sec. 461-467	Provides for the protection of natural landmarks.
Fish and Wildlife Coordination Act	16 USC 661-667 E	All agencies regulating activities that may have an effect on either fish or wildlife must notify and allow input by agencies overseeing fish and wildlife habitats in the area of the proposed activities.
Coastal Zone Management Act	16 USC 1451 et seq. 15 CFR Parts 923, 928, 932	Provides for the proper maintenance and upkeep of all coastal areas. Protects coastal resources.
Wetlands Protection	310 CMR 10.00-10.99	Establishes State of Massachusetts regulations for protection of coastal and inland wetlands, including compliance with the Massachusetts Environmental Policy Act.





**TABLE 4-5**  
**POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Solid Waste Disposal Act	42 USC Sec. 6901-6987	Resource Conservation and Recovery	
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and thereby prohibit open dumps.	Not Applicable
Criteria for Municipal Solid Waste Disposal Facilities	40 CFR Part 258	Establishes minimum federal criteria for design, construction, operation, and permitting of municipal solid waste landfills.	Not Applicable
Identification and Listing of Hazardous Waste	40 CFR Part 261	Defines those solid wastes which are subject to regulation as hazardous waste.	Applicable for defining whether or not hazardous waste is generated
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	Establishes standards for generators of hazardous waste	Applicable. If remedial action causes hazardous waste to be generated, these standards will apply
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards which apply to persons transporting hazardous waste within the U.S.	Applicable. If hazardous waste is transported off-site, these standards will apply





**TABLE 4-5**  
**POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264	Establishes minimum national standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose of hazardous waste.	Applicable for hazardous waste management activities during remediation
Standards for Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities	40 CFR Part 266	Establishes requirements which apply to recyclable materials used in a manner constituting disposal or hazardous waste burned for energy recovery.	If hazardous wastes are recycled on or off-site, these standards are applicable
Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities	40 CFR Part 267	Establishes minimum national standards that define acceptable management of hazardous waste land disposal facilities.	Applicable if hazardous waste is present
Land Disposal Restrictions (LDR) Program	40 CFR Part 268	Sets treatment standards for hazardous wastes based on the levels achievable by current technology; sets two-year national variances from the statutory effective dates due to insufficient treatment capacity.	Applicable for hazardous wastes destined for land disposal
Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (USTs)	40 CFR Part 280	Provides regulations pertaining to underground storage tanks.	Applicable if there is operation or removal of an UST





**TABLE 4-5**  
**POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
<b>Clean Water Act</b>	33 USC Sec. 1251-1376		
EPA-Administered Permit Programs: The National Pollutant Discharge Elimination System	40 CFR Part 122	Requirements for the discharge of pollutants from any point source into waters of the U.S.	Applicable if remedial action requires outfall discharge
Criteria and Standards for the National Pollutant Discharge Elimination System	40 CFR Part 125	Provides discharge criteria, chemical standards, and permit forms for existing industrial operations.	Applicable to remedial actions which cause discharge to waters of the U.S.
<b>Occupational Safety and Health Act of 1970</b>	29 USC Sec. 657 and 667		
Occupational Safety and Health Standards	29 CFR Part 1910	Sets standards for safety in the work environment.	Applicable to all remedial actions
Safety and Health Regulations for Construction	29 CFR Part 1926	Sets standards for safety in the construction work environment.	Applicable to all remedial actions
Safety and Health Standards for Federal Service Contracts	29 CFR Part 1925	States that safety and health standards are applicable to work performed under Federal Service Contracts.	Applicable to all remedial actions
<b>Clean Air Act</b>			





**TABLE 4-5**  
**POTENTIAL ACTION-SPECIFIC FEDERAL ARARS AT FORT DEVENS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
National Emissions Standards for Hazardous Air Pollutants	40 CFR Part 61	Establishes emissions standards for hazardous air pollutants that may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible, or incapacitating illness.	Applicable to incineration, storage of petroleum liquids; and air stripping activities
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes standards for ambient air quality to protect public health and welfare.	Applicable if there are any air emissions during remediation
Safe Drinking Water Act	40 USC Sec. 300G		
Underground Injection Control Program	40 CFR Part 144	Provides for protection of underground sources of drinking water.	Applicable to underground injection of wastes/contaminated water
Underground Injection Control Program: Criteria and Standards	46 CFR Part 146	Provides technical requirements for UIC programs.	Applicable to underground injection of wastes/contaminated water
Department of Transportation - Hazardous Materials Regulations			
Shipping and Manifesting Requirements for Hazardous Waste	49 CFR Parts 171-179	Provides requirements for packaging, manifesting, and transportation of hazardous waste.	Applicable if offsite shipment of wastes occurs





## 5.0 AOC 43J REMEDIAL INVESTIGATION

### 5.1 BACKGROUND AND CONDITIONS

AOC 43J is located on an access road in the central portion of the Main Post, that connects Patton Road and Queenstown Road. The area around the location of AOC 43J, is presently a vehicle storage yard and maintenance facility (Building T-2446) for a Special Forces Unit of the U.S. Army. The yard and maintenance facility is paved with asphalt and surrounded by a chain-link fence with a locked gate located at the northern side of the yard (Figure 5-1).

Prior to the building of the Special Forces Unit vehicle maintenance facility, this area was historically used as a gas station/motor pool during the 1940's and 1950's. The structure of this historic gas station at AOC 43J consisted of a pump island and a small gasoline pumphouse. This gas station was reported to be a Type A station which had one 5,000-gallon (or possibly 5,140-gallon) UST located between the gasoline pumphouse and pump island. The station was used during World War II as a vehicle motor pool to support military operations. The motor pool operations were discontinued during the late 1940s or early 1950s. No records were available on the decommissioning of this motor pool or the removal of the associated UST.

### 5.2 SUMMARY OF PREVIOUS REMOVAL ACTIONS

The following subsections discuss previous removal actions performed by Fort Devens contractors at AOC 43J. A brief summary of analytical data is presented to demonstrate the need for subsequent investigations at the site. A complete assessment of the analytical data is presented in Section 7.0 of the RI Report. The scope of each investigations' activities performed at AOC 43J is summarized in Table 5-1.

#### 5.2.1 May 1992 1,000 Gallon Waste Oil UST Removal

Prior to ABB-ES's SI field program, Fort Devens began removing USTs as part of the installation's environmental restoration program. As part of this 1992 UST

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removal program, ATEC Environmental Consulting Services (ATEC), the Fort Devens UST removal contractor, removed one 1,000-gallon waste oil UST approximately 50 feet east of the historic gas station UST at AOC 43J (Figure 5-2). This UST was used by the existing Special Forces unit for the storage of waste oil generated from the maintenance operation at this facility. Ten field screening samples (SS-1 through SS-10), and two laboratory analytical samples (LSS-1 and LSS-2), were collected to assess impact from leaks and spills associated with the UST. Analyses performed on the samples are summarized in Table 5-2. Due to unknown distribution of the soil contamination, and limitations in ATEC's contract, not all of the contaminated soil was removed. Analysis of laboratory analytical samples from the excavation revealed TPHC concentrations of 74 parts per million (ppm) (LSS-1) and 918 ppm (LSS-2) (Table 5-3).

Under direction from the Fort Devens Environmental Management Office (EMO) representative, ATEC backfilled the excavation and removed the stockpiled soil for disposal. As part of the UST removal program, ATEC installed four monitoring wells (2446-01 through 2446-04) around the area of the former 1,000-gallon waste oil UST (see Figure 5-2). Each of these monitoring well screens intersect the water table and are installed across the soil/bedrock interface. These monitoring wells were designed to determine the groundwater quality upgradient and downgradient of the former waste oil UST. The boring logs and well installation diagrams are presented in Appendix A and C, respectively. Tables 5-4 and 5-5 summarize the soil boring findings and the monitoring well installation diagrams. One round of groundwater samples was collected from these wells by ATEC. These groundwater samples were analyzed by a non-USAEC-approved laboratory for TPHC only. The results of the analyses show detectable concentrations of TPHC ranging from 3 mg/L in 2446-04 to 140 mg/L in 2446-03. TPHC was not detected in 2446-01 (ATEC, 1992a) (see Table 5-3). A complete discussion of ATEC's results are presented in Section 7.0 of this report.

### **5.2.2 August 1992 Historic Gas Station J 5,000 Gallon Gasoline UST Removal**

As part of the SI, ABB-ES conducted a geophysical survey at historic gas station J (SA 43J) to determine the presence or absence of an abandoned UST. The results of the geophysical survey indicated that an abandoned UST was present at the historic gas station. The UST discovered at AOC 43J was added to the Fort

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Devens UST removal program, and on August 26, 1992 ATEC removed a 5,000-gallon steel UST. At the time of the removal, tank contents consisted of gasoline and sludge. Visually contaminated soil and strong fuel odor were present in the excavation (ATEC, 1992b). ATEC performed headspace screening for total VOCs and nondispersed infrared (NDIR) spectroscopy for TPHC on eight soil samples (SS-1 through SS-8) collected from the sides and bottom of the UST excavation (see Figure 5-2). VOC concentrations ranged from 100 to 400 ppm in the sample headspace, and TPHC concentrations ranged from 43.9 to 3,534.8 ppm (ATEC, 1992b) (Table 5-6). An inspection of the UST was completed by the Fort Devens EMO's on-site representative and a representative of the MADEP. This inspection did not find any obvious holes or breaks in the walls of the UST. An Underwriters Laboratory (UL) tag found on the UST appeared to indicate that this UST was of a younger age than the reported age of the historic gas station at AOC 43J. The conclusion reached by Fort Devens and MADEP personnel was that the original UST had been replaced by the UST that was removed during this removal program, and that the contamination detected, in the excavation, appeared to be caused by the original UST, not the abandoned UST found at AOC 43J.

Based on these field screening results, additional soil was removed from this excavation by ATEC in an effort to remediate the observed soil contamination. Groundwater was encountered in the southeastern corner of the excavation, and bedrock was reached at approximately 7 feet below ground surface (bgs). From the observations made in the UST excavation, it appeared that the water table below the former UST was below the bedrock surface. The lateral distribution of the contamination was not determined during this cleanup process due to physical restriction (e.g., driveways, buildings, stockpiled soil). After additional soil was removed from the excavation, ATEC collected five soil samples (LRS-1 through LRS-4 and LSS-1) and one water sample (LWS-1) from the side walls and bottom of the UST excavation for off-site laboratory analysis (see Figure 5-2). Soil samples LRS-3 was analyzed for VOCs and TCLP metals (see Table 5-2). The remainder of the samples were analyzed by a non-USAEC-approved laboratory for TPHC. The results for LRS-3 indicated a xylene concentration of 1.65 ppm. TPHC concentrations detected in the other soil samples ranged from 38 ppm to 2,170 ppm. Groundwater sample LWS-1 contained 114 ppm of TPHC (see Table 5-6). Because of these results, the EMO representative decided to stop the cleanup process, line the excavation with polyethylene sheeting, and backfill the

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excavation with clean fill. ATEC completed these tasks and the area was paved (ATEC, 1992b). A complete discussion of ATEC's results are presented in Section 7.0 of this report.

### 5.3 PREVIOUS INVESTIGATIONS

The followings subsections discuss investigations performed by ABB-ES at AOC 43J prior to the RI. A brief summary of analytical data is presented to demonstrate the need for subsequent investigations at the site. A complete assessment of the analytical data is presented in Section 7.0 of this RI Report.

#### 5.3.1 1992 Site Investigation Program

The SI at AOC 43J was started in May 1992, in accordance with the Historic Gas Stations SI Task Order Work Plan (ABB-ES, 1992b) and in conformance with the provisions of the Fort Devens POP (ABB-ES, 1992a). Table 5-1 summarizes the scope of investigations completed during the SI.

**5.3.1.1 Summary of Site Investigation Activities.** The SI at AOC 43J focused in and around the former abandoned gasoline UST located at the historic gas station (Figure 5-3). The activities consisted of the following:

- A geophysical program was conducted consisting of a metal detector and ground-penetrating radar (GPR) survey.
- A total of eight TerraProbe<sup>™</sup> points were completed and up to two soil samples per point were collected for field analysis.
- One soil boring (43J-92-01X) was completed and one subsurface soil sample was submitted for off-site laboratory analysis.

The geophysical program conducted at AOC 43J in May 1992 consisted of a metal detector and GPR survey. The survey covered the entire area suspected to be historic gas station J, to confirm the presence or absence of the abandoned UST. A 5,000-gallon gasoline UST was detected with the metal detector and the location of the ends and sides of the UST were estimated with the GPR. The

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results of the geophysical surveys are presented in Appendix B. This UST was removed by ATEC in August 1992 (see previous Subsection 5.2.2).

Because bedrock was encountered at approximately 8 to 10 feet bgs, only nine subsurface soil samples were collected from eight TerraProbe<sup>SM</sup> points: TS-01, TS-03, and TS-05 through TS-10 (see Figure 5-3). Five soil samples were collected from 4 feet to 5 feet bgs, and four soil samples were collected from 9 feet bgs (apparent top of bedrock). All of the soil samples were analyzed in the field for BTEX and TPHC (see Table 5-2).

Because of the results of the TerraProbe<sup>SM</sup> program, one soil boring (43J-92-01X) was drilled to collect subsurface soil samples for off-site laboratory analysis (see Figure 5-2). Due to subsurface obstructions, only one soil sample was collected from the top of bedrock at 6.2 feet bgs in this boring. This soil sample was analyzed for VOCs, TPHC, and lead (see Table 5-2). The boring log is presented in Appendix A and summarized in Table 5-4.

**5.3.1.2 Field Analytical Results.** Total BTEX concentrations in the TerraProbe<sup>SM</sup> soil samples ranged from 3,600  $\mu\text{g/g}$  in the 9 foot sample collected from TS-01 to 81,000  $\mu\text{g/g}$  in the 9 foot sample collected from TS-03. TPHC concentrations ranged from 130  $\mu\text{g/g}$  in the 4 foot sample collected from TS-05 to 940  $\mu\text{g/g}$  in the 9 foot sample collected from TS-03 (Table 5-7). All of the TerraProbe<sup>SM</sup> points encountered refusal prior to reaching the water table. A detailed discussion of the field analysis results is presented in Section 7.0 of this report.

**5.3.1.3 Laboratory Analytical Results.** The results for the soil sample collected from 43J-92-01X indicated that xylenes (0.02  $\mu\text{g/g}$ ), TPHC (1,770  $\mu\text{g/g}$ ) and lead (10.9  $\mu\text{g/g}$ ) were present in this soil sample (Table 5-8 and 5-9). A complete discussion of the off-site laboratory results is presented in Section 7.0 of this report.

### **5.3.2 Site Investigation Conclusions and Recommendations**

The conclusion drawn from the data collected during the ATEC UST removals and the SI field investigation was that the contents of the abandoned gasoline UST and the former waste oil UST had contaminated the soil and groundwater at AOC 43J. Since the investigation had focused on the subsurface, no ecological



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preliminary risk evaluation (PRE) was conducted. A human health PRE was conducted at the AOC as part of the SI. This PRE indicated that the existing petroleum contamination in soil represented a potential risk to public health. It was therefore recommended that an SSI be conducted at AOC 43J to further define the distribution of petroleum contamination in soil and groundwater.

The following subsections address the SSI sampling rationale and field program.

### 5.3.3 1993 Supplemental Site Investigation Program

The SSI at AOC 43J was performed in accordance with the SSI Task Order Work Plan (ABB-ES, 1993e) and in conformance with the provisions of the Fort Devens POP (ABB-ES, 1993d). The following subsections describe the field activities completed at this historic gas station during the SSI. Table 5-1 summarizes the scope of the SSI at AOC 43J.

**5.3.3.1 Summary of Supplemental Site Investigation Activities.** The SSI at AOC 43J was conducted during August, 1993. The investigation was focused on the soil in and around the former waste oil UST located south of Building 2446 and the groundwater at AOC 43J (Figure 5-4). The activities consisted of the following:

- A total of 15 TerraProbe<sup>™</sup> points (TS-11 through TS-14, TS-16 through TS-20, and TS-22 through TS-27) were completed, and up to two soil samples per point were collected and analyzed in the field. TerraProbe<sup>™</sup> points TS-15 and TS-21 were not sampled due to subsurface destructions.
- Four groundwater monitoring wells (XJM-93-01X through XJM-93-04X) were installed to supplement the four existing monitoring wells.
- One soil sample was collected from three of the four monitoring well borings for off-site laboratory analysis.
- Two rounds of groundwater samples (Round Three and Four) were collected from the four newly installed monitoring wells and from three of the four existing monitoring wells (2446-02 through

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2446-04). Existing monitoring well 2446-01 was not sampled because it had been damaged.

- Hydraulic conductivity tests were conducted on the four newly installed monitoring wells.

The 15 TerraProbe<sup>™</sup> points were advanced in and around the excavation of the former waste oil UST removed in 1992 (see Figure 5-4). These soil samples were collected to further define the horizontal distribution of contaminants detected during the SI. One soil sample was collected from the top of bedrock surface at each of the TerraProbe<sup>™</sup> points. The samples were analyzed in the field laboratory for BTEX and TPHC (see Table 5-2).

Four groundwater monitoring wells (XJM-93-01X through XJM-93-04X) were installed to monitor upgradient and downgradient groundwater quality (see Figure 5-4). Soil samples were collected from the water table or the bedrock surface in three of the four monitoring well borings for off-site laboratory analysis. The soil sample from the monitoring well boring for XJM-93-01X was collected from the top of bedrock, and the samples from XJM-93-02X and XJM-93-03X were collected from the water table in overburden soils. No soil sample was collected from XJM-93-04X due to the extremely shallow depth to bedrock (0.7 feet bgs). The soil samples were submitted for off-site laboratory analysis of PAL VOCs, SVOCs, inorganics, TPHC, and TOC (see Table 5-2). The well screen of each monitoring well was placed so that it intersected the water table to monitor for free product and allow for seasonal groundwater fluctuations. The well screens in the monitoring wells installed at XJM-93-01X and XJM-93-04X were installed in the bedrock. The well screens in the monitoring wells at XJM-93-02X and XJM-93-03X were installed in overburden soils. Boring logs and well construction diagrams are included in Appendix A and C, respectively, and are summarized in Tables 5-4 and 5-5.

The soil encountered during the SSI at AOC 43J consisted of a poorly graded silty sand (which appeared to be fill material) underlain by a fine sandy silt with fine gravel (glacial) till). Bedrock was encountered at AOC 43J at a depth of 0.7 and 13.5 feet bgs. The bedrock at this site was classified as metasiltstone or phyllite. The boring logs for these monitoring well borings are presented in Appendix A,



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and summarized in Table 5-4. A detailed discussion of the geologic setting at AOC 43J is presented in Section 6.0 of this report.

After the newly installed monitoring wells were developed, two rounds of groundwater samples (Rounds Three and Four) were collected from the four newly installed, and three of the existing, monitoring wells in October 1993 and January 1994. These samples were submitted for laboratory analysis of PAL VOCs, SVOCs, inorganics (both filtered and unfiltered), TPHC, and TSS (see Table 5-2).

After the newly installed monitoring wells were developed and sampled, in-situ hydraulic conductivity tests were performed. The tests consisted of rising and falling head tests. Hydraulic conductivity tests were not performed at XJM-93-02X because only 2 feet of water was present in the monitoring well at the time of the testing.

Each of the explorations completed during the SSI was surveyed for vertical and horizontal control.

**5.3.3.2 Field Analytical Results.** A total of 15 TerraProbe<sup>sm</sup> points were completed and soil samples were collected from 9 to 10 feet bgs (the top of the bedrock), and analyzed for BTEX and TPHC (see Table 5-2). The TerraProbe<sup>sm</sup> points were concentrated in and around the former waste oil UST excavation in front of Building 2446 (see Figure 5-4). The results of the field analyses indicate the presence of toluene, ethylbenzene and xylenes (TEX) in and around the former waste oil UST excavation. The total TEX concentrations ranged from below the detection limit (at apparent upgradient locations TS-12 and TS-13) to 12,100  $\mu\text{g/g}$  at the northeast (TS-25) side of the excavation. TPHC was detected less frequently than TEX, and ranged from below the detection limit to 3,100  $\mu\text{g/g}$  at TS-25 (see Table 5-7). The distribution of the contamination was roughly defined on the northwest and west sides of the excavation, however the northeast, east and southern sides were not fully defined. A detailed discussion of these results is presented in Section 7.0 of this report.

**5.3.3.3 Off-site Laboratory Analytical Soil Results.** Subsurface soil samples were collected from three of the four monitoring well borings (XJM-93-01X through XJM-93-03X) completed at AOC 43J. A subsurface soil sample was not collected

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from XJM-93-04X due to the very shallow depth to bedrock (0.7 feet bgs). No VOCs or SVOCs were detected in the subsurface soil samples collected. The results of the laboratory analyses did indicate the presence of several inorganic analytes above the Fort Devens background concentrations. The majority of these analytes were detected in the 5-foot sample from XJM-93-02X located on the southern side of Building 2446. TPHC was also detected in this sample at 220  $\mu\text{g/g}$  (see Table 5-8 and 5-9). TPHC was not detected in the other samples collected. A detailed discussion of these results is presented in Section 7.0 of this report.

**5.3.3.4 Off-site Laboratory Analytical Groundwater Results.** The results of Round Three groundwater sampling indicated that several VOCs (including benzene at concentrations ranging from 6.3  $\mu\text{g/L}$  to 200  $\mu\text{g/L}$ ) were present in three of the newly installed monitoring wells (XJM-93-02X through XJM-93-04X located north, southeast, and south of the UST excavations) and in each of the existing monitoring wells sampled during this round (2446-02 through 2446-04). Total VOCs ranged from 8.9  $\mu\text{g/L}$  at XJM-93-02X to 18,200  $\mu\text{g/L}$  at 2446-02. Several SVOCs (2-methylnaphthalene, naphthalene and phenanthrene) and TPHC were also detected in these same monitoring wells. Several inorganic analytes were detected above the Fort Devens background concentrations in the unfiltered and filtered samples. In the filtered samples, these included antimony, arsenic, calcium, iron, lead, magnesium, manganese, potassium, and sodium (Table 5-10).

The results of Round Four groundwater sampling indicated that several VOCs (including benzene at concentrations ranging from 20.0  $\mu\text{g/L}$  to 200  $\mu\text{g/L}$ ) were present in three of the newly installed monitoring wells (XJM-93-02X through XJM-93-04X) and in each of the existing monitoring wells. Total VOCs ranged from 240  $\mu\text{g/L}$  at XJM-93-02X to 23,000  $\mu\text{g/L}$  at 2446-02. Several SVOCs (2-methylnaphthalene, naphthalene and phenanthrene) and TPHC were also detected in these same monitoring wells. Several inorganic analytes were detected above the Fort Devens background concentrations in both the unfiltered and filtered samples. In the filtered samples, these included antimony, arsenic, calcium, iron, lead, magnesium, manganese, potassium, and sodium (see Table 5-10). A complete discussion of these groundwater results is presented in Section 7.0 of this report.



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### **5.3.4 Supplemental Site Investigation Conclusions and Recommendations**

The results of the SSI sampling indicated that additional contaminated soil was present below the former waste oil UST location and that the groundwater quality at the site had been adversely impacted from potential leaks and spills associated with the former USTs. The SI human health PRE was revised based on the off-site laboratory results from the SSI sampling at AOC 43J. The results of the revised PRE indicated that there was a potential risk to human receptors in a residential exposure scenario associated with VOCs (BTEX) and inorganics in groundwater. As a result, it was determined that RI activities at AOC 43J were required to (1) determine the source and distribution of the VOC and inorganic groundwater contamination and (2) define the distribution of soil contamination detected during the SI and the SSI. The collection of this additional data would also allow for a more comprehensive human health risk evaluation.

The following subsections address the RI technical objectives, sampling rationale, and field program.

### **5.4 REMEDIAL INVESTIGATION PROGRAM OBJECTIVES**

#### **5.4.1 Technical Objectives**

The following subsections present the technical objectives of the sampling and analysis programs completed for the RI at AOC 43J.

**5.4.1.1 Soil Borings.** The technical objective of the soil boring program was to obtain representative soil samples for conducting field analysis, laboratory analyses, determine the horizontal and vertical distribution of soil contamination, further define the depth to bedrock, and determine textural characteristics of the soil. In addition, the borings were intended to yield sufficient data to further define the geologic setting at AOC 43J. This includes location of the site within the regional stratigraphic setting and identification of fine-grained soil layers, as well as determining the type of, and depth to, bedrock.

**5.4.1.2 Monitoring Wells.** The technical objective of the monitoring well program was to install monitoring wells in geologic units such that the local groundwater

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flow system and contaminant distribution could be adequately characterized. This included collecting water level data to establish flow directions and horizontal gradients, and to estimate the hydraulic conductivity of the geologic units.

**5.4.1.3 Field Laboratory Analysis.** The technical objective of the field analytical program was to relatively quickly generate USEPA Level II analytical data for previously identified site-related compounds (specifically BTEX and TPHC) that allowed for preliminary identification of their distribution. This information enabled accurate placement of soil borings and groundwater monitoring wells. In addition, this field analytical data was used to support the results and findings of the contaminant assessment and human health risk assessments. The field analytical techniques employed as part of this RI are discussed in detail in Subsection 3.1 of this report. The results of the field analyses are discussed in detail in Section 7.0 of this report.

**5.4.1.4 Off-Site Analytical Sampling.** The technical objective of the analytical sampling program was to enhance the analytical data base for subsurface soil and groundwater at AOC 43J. This data base was used as the foundation for contamination assessment, the fate and transport discussion, and the human health risk assessment. The laboratory analytical methods employed as part of this RI are discussed in detail in Subsection 3.2 of this report. The results of the analytical data are discussed in detail in Section 7.0 of this report and presented in Appendix M.

#### **5.4.2 Data Quality Objectives**

Data Quality Objectives (DQOs) are qualitative or quantitative statements developed by the data user to specify the quality of data needed from a particular activity to support specific decisions. The DQOs are the starting point in the design of the remedial investigation. The DQO development process matches sampling and analytical capabilities to the data targeted for specific uses and ensures that the quality of the data does not underestimate project requirements.

The procedures of the QA Objectives presented in Section 3.0 of Volume I of the Fort Devens POP were followed during the RI field program at AOC 43J (ABB-ES, 1993c). This subsection includes a general scope of work, DQOs and the QA/QC approach.

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Analyses were conducted on samples collected from AOC 43J to evaluate the nature and distribution of the contaminants detected in the previous investigations. On-site field analysis conformed with the guidelines presented in Subsection 4.6 of Volume I of the Fort Devens POP. Off-site laboratory analytical procedures are presented Section 7.0 of Volume I of the POP, and the Laboratory QA Plan and the USAEC Certified Analytical Methods procedures are presented in Appendices B and C, respectively, in Volume II of the Fort Devens POP (ABB-ES, 1993c).

The USEPA has identified five general levels of analytical data quality as being potentially applicable to field investigations conducted at potential hazardous waste sites under CERCLA. These levels are summarized as follows:

- Level I - Field Screening. This level is characterized by the use of portable instruments that can provide real time data to assist in the optimization of sampling point locations and for health and safety support. Data can be generated regarding the presence or absence of certain contaminants (especially volatiles) at sampling locations.
- Level II - Field Analysis. This level is characterized by the on-site use of portable analytical instruments and mobile laboratories that can render qualitative and quantitative data.
- Level III - Laboratory analysis using methods other than the Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is used primarily in support of engineering studies using standard USEPA-approved procedures. Some procedures may be equivalent to the USEPA RAS, without the CLP requirements for documentation.
- Level IV - CLP RAS. This level is characterized by rigorous QA/QC protocols and documentation, which provide qualitative and quantitative analytical data.
- Level V - Non-standard methods. This level includes analyses which may require modification and/or development. CLP Special Analytical Services (SAS) are considered Level V.

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For AOC 43J RI efforts, field measurements such as pH, temperature, conductivity, and readings from a PID and Oxygen/Explosimeter constituted Level I field analytical data. Field GC analysis constituted Level II field analytical data. Off-site laboratory analyses of soil and groundwater for organics, inorganics, TOC, TPHC, water quality parameters, pesticides and PCBs, and explosives were considered approximately equivalent to USEPA analytical support Level III. The sampling approaches and analytical procedures described in the ABB-ES Fort Devens POP have been selected to meet the Level III data quality.

DQOs were established to support the level of detail required for RI activities. Data generated during the field and laboratory tasks were used to characterize AOC 43J conditions and to perform baseline risk assessments.

DQOs and QC for field measurements and laboratory analyses conform to USAEC and USEPA requirements (as specified in the USAEC Quality Assurance Manual, 1990 and Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, 1988).

USAEC requirements and analytical processes are discussed in Section 3.0 of this report. They focus on the use of laboratory control spikes in associated data lots to measure the performance of the laboratory in the use of USAEC methods. Many of the USAEC methods are identical to standard USEPA methods. The certification process, required by laboratories performing USAEC work, is discussed in Subsection 3.2.1. The data review and evaluation process are described in Subsection 3.2.6.

Laboratory data were evaluated for precision, accuracy, representativeness, completeness and comparability (PARCC) in order to meet USEPA Level III requirements. This was accomplished through the collection of field QC blanks such as field blanks, trip blanks and equipment rinsates, and through the evaluation of laboratory blanks such as method blanks. The specific purpose of collecting each of these is discussed in Subsection 3.2.5 of this report. Laboratory control spikes are run in the certification process to generate control charts that help to establish control limits that are used to ensure accuracy of the results. This process is described in the text of the report in Subsection 3.2.5. MS/MSD samples and duplicate samples were also analyzed to meet PARCC data quality objectives. These are broken down by group and are presented in Appendix D.

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The precision of the data is a measurement of the ability to reproduce a value under certain conditions. It is a quantitative measurement based on the differences of two values. Precision was evaluated using the RPD of MS/MSD sample pairs and field duplicate sample pairs. Evaluations of the precision of the data are found in Appendix D.

Accuracy measurements identify the performance of a measurement system based on tests with known values. The laboratory, sampling, and media effects on accuracy were assessed by reviewing the percent recoveries of spiked analytes for MS/MSDs, laboratory control samples, and surrogate compounds.

Representativeness refers to the extent to which a measurement accurately and precisely represents a given population within the accepted variation of laboratory and sampling measurements. Collection techniques that obtained samples characteristic of the matrix and location being evaluated were chosen. Historic information was used to identify sample locations. Representativeness was also evaluated using method blanks and field QC sample data. By evaluating method blank and field QC samples, false positive results should be identified. Representativeness was also measured by evaluating field duplicate pair precision.

Completeness refers to the percentage of usable, valid values obtained through data evaluation. Completeness was determined by the success rate in meeting holding time criteria and acceptance of sample lots by USAEC.

Comparability is a qualitative assessment describing the confidence with which one data set may be compared with another. Comparability was assured using standard operating procedures for sampling, and by reporting analytical results in standard units.

### 5.5 SUMMARY OF 1994 REMEDIAL INVESTIGATION PROGRAM

The RI techniques used at AOC 43J were conducted in conformance with the Revised Final Task Order Work Plans for AOC 41, AOC 43G, and AOC 43J (ABB-ES, 1994b) and the Revised Final POP (ABB-ES, 1993c). A summary of investigation activities completed during the RI is presented in Table 5-1. Locations of RI explorations are presented in Figures 5-5 and 5-6.

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The RI program for AOC 43J consisted of:

- geophysical survey consisting of a GPR survey to clear exploration locations and a seismic refraction survey to further define the bedrock surface at this AOC;
- a total of 48 TerraProbe<sup>sm</sup> points east-southeast of the former UST locations;
- drilling and sampling of nine screened auger borings (SAJ01 through SAJ10);
- drilling and sampling 15 soil borings (XJB-94-02X through XJB-94-16X);
- field analysis of soil and groundwater samples from screened auger, TerraProbe<sup>sm</sup> points, and soil borings using a field GC and IR;
- installing six monitoring wells (XJM-94-05X through XJM-94-10X);
- installing two piezometers;
- well development;
- two rounds of groundwater sampling from six new and seven existing monitoring wells;
- laboratory analysis of environmental samples;
- aquifer conductivity testing; and
- site topographic survey and vertical and horizontal survey of explorations.

ABB-ES established a project field office in Building 201 on Fort Devens' Main Post. The field office was used for equipment storage and maintenance, sample management, shipping and receiving, staff meetings, and communications. A

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telephone was maintained in the field office and each field crew was issued a hand-held cellular phone. An equipment decontamination pad was constructed near the field office. ABB-ES and subcontractor staff were briefed about the nature of the AOC 43J, health and safety information, Fort Devens traffic regulations, and key technical requirements.

ABB-ES began implementation of the AOC 43J field program in September 1994, with equipment mobilization and GPR survey for boring clearance.

The subcontractors assisting ABB-ES in conducting the RI field program were as follows:

- D.L. Maher, North Reading, MA - Drilling and monitoring well installation.
- ESE, Gainesville, FL - Chemical analysis of environmental samples.
- Martinage Engineering Assoc., Inc., Reading, MA - Surveying of site explorations.
- Geophysics GPR International Inc. - Seismic refraction survey.

All field activities were conducted in accordance with the Fort Devens POP (ABB-ES, 1993c) and USAEC's Geotechnical Guidelines (USAEC, 1987). The following subsections describe the RI field activities performed at AOC 43J.

### 5.5.1 Surficial Geophysical Survey

A surficial geophysical survey using GPR was conducted in August 1993 to locate safe drilling locations for all of the intrusive exploration completed during the RI. The surficial geophysical survey procedures are outlined in Subsection 4.4.3 of Volume I of the Fort Devens POP (ABB-ES, 1993d).

### 5.5.2 Seismic Refraction Survey

A seismic refraction survey was conducted in December 1994 by Geophysics GPR International, Inc. (GPRI) of Needham Heights, MA to further define the

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bedrock surface of AOC 43J. Three seismic lines (lines 1 through 3) were completed outside the fenced area at AOC 43J (see Figure 5-5). A summary of the technique and procedures employed is presented below; the complete report GPRI is presented in Appendix B.

A 24-channel EG&G Smartseis S24 digital seismograph was employed during this investigation. Amplification of the signals from the geophones was accomplished using integrated floating point technology, which allows maximum trace size throughout the record. Each seismogram was recorded digitally on the seismograph hard drive, transferred to floppy disk, and printed on-site.

The major energy source was electrical percussion detonated by a shotbox. The shotbox delivered a 67.5 volt, 2 amp electric impulse via the blasting cable to each charge. When a shot was fired, an impulse from the shotbox was sent to the shot instant recording galvanometer which marks the zero time on the first trace of each seismogram.

Seismic profiles were conducted across four separate lines of approximately 1,380 linear feet (see Figure 5-5). The seismic refraction survey was conducted with a uniform geophone spacing of 15 and 20 feet, yielding spread lengths of 345 and 460 feet, respectively, and required three days of field surveys. None of the spreads were contiguous; however, two of the spreads crossed each other. Three to five shotpoints were used for each spread of geophones. These shotpoints provide information on the acoustic velocity of the overburden and permit an estimate of the velocity and depth to rock. In-line offset shots were fired beyond the end of each spread in the forward and reverse directions. The offset distance was such that the first arrivals at each geophone were refracted from the bedrock. Offset shotpoints provide detailed information on the topographic profile and velocity of the bedrock.

### **5.5.3 TerraProbe<sup>SM</sup> Soil Sampling**

Forty-eight TerraProbe<sup>SM</sup> points were completed southeast of the former UST locations to further define the vertical and horizontal distribution of the soil contamination detected during the previous investigation (see Figure 5-6). Up to two soil samples were collected from each point and analyzed in the field for BTEX and TPHC (see Table 5-4). One soil sample was collected from

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approximately 7 to 9 feet bgs to define soil contamination above the water table; and the second soil sample was collected from approximately 9 to 11 feet bgs to further define soil contamination at the water table. The first TerraProbe<sup>sm</sup> points were located along a 125-foot by 300-foot grid east of the former UST excavations, which was tied into the previous TerraProbe<sup>sm</sup> sampling locations completed during the SI and SSI. The TerraProbe<sup>sm</sup> points were spaced along the grid at 15-foot increments. The grid lines were separated by 20 feet (see Figure 5-6). Sampling procedures are presented in Subsection 4.5.1.3 of Volume I of the Fort Devens POP (ABB-ES, 1993d). Sample results are discussed in detail in Section 7.0 of this report.

### 5.5.4 Soil Borings and Soil Sampling

A total of 15 soil borings (XJB-94-02X through XJB-94-16X) were completed during the RI. Soil borings XJB-92-02X, XJB-94-03X, and XJB-94-16X are coincident with screened auger borings SAJ04, SAJ02, and SAJ08, respectively (see Figure 5-5). Soil samples were collected at a minimum of 5-foot intervals from each boring. The soil samples collected from each boring were used for soil classification, field analytical samples and off-site laboratory samples. Soil samples were analyzed in the field for BTEX and TPHC and at the off-site laboratory for PAL VOCs, SVOCs, inorganics, and TPHC (see Table 5-4). These soil borings were completed to further define the vertical and horizontal distribution of soil contamination. The borings were located adjacent to TerraProbe<sup>sm</sup> points to confirm field analytical results. Soil boring and sampling procedures are presented in Subsection 4.5.1.3 of Volume I of the Fort Devens POP (ABB-ES, 1993d). Soil boring logs are presented in Appendix A and summarized in Table 5-5. Sample results are discussed in Section 7.0 of this report.

### 5.5.5 Screened Auger Borings

A total of 10 screened auger borings (SAJ01 through SAJ10) were completed at AOC 43J (see Figure 5-5). Screened auger borings SAJ02, SAJ04, and SAJ08, are coincident with soil borings XJB-94-03X, XJB-94-02X, and XJB-94-16X, respectively. Screened auger locations SAJ01, SAJ03, SAJ06, SAJ07, and SAJ08 were located outside the groundwater contaminant plume. The remaining screened auger borings, SAJ02, SAJ04, SAJ05, SAJ09, and SAJ10 were located

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within the groundwater contaminant plume. One groundwater sample was collected from the water table at each location. The groundwater samples were analyzed using a field GC for BTEX and selected chlorinated solvents (see Table 5-4). The results of the field analysis were used to determine the horizontal distribution of the VOC (BTEX) contamination previously detected in the groundwater at AOC 43J. The field analytical procedures are presented in Subsection 3.1 of this report, and Subsection 4.6 of Volume I of the Fort Devens POP (ABB-ES, 1993d). Screened auger sampling procedures are presented in the Fort Devens POP (ABB-ES, 1995). Screened auger boring logs are presented in Appendix A. A detailed discussion of the sample results is presented in Section 7.0 of this report.

#### **5.5.6 Monitoring Well/Piezometer Installation**

Based on the results of the TerraProbe™ program, the soil boring program, and the screened auger boring program, a total of six new water table groundwater monitoring wells (XJM-94-05X through XJM-94-10X) were installed downgradient and crossgradient from the former UST excavations during the RI (see Figure 5-5). Each of the well screens for these new monitoring wells were installed in overburden soil. The well screen for monitoring well XJM-94-07X was screened through a boulder, which at the time of well installation was thought to be bedrock. Monitoring well construction was completed in accordance with USAEC requirements. A summary of monitoring well completion details is presented in Table 5-9. Procedures for monitoring well/piezometer installation are presented in Subsection 4.4.6.4 of Volume I of the Fort Devens POP (ABB-ES, 1993d). Well construction diagrams are presented in Appendix C.

#### **5.5.7 Well Development**

Each of the newly installed RI monitoring wells were developed using the pump and surge method, to remove any water added to the boring during drilling and/or well installation, and to remove sediment from the monitoring well screen prior to groundwater sampling and aquifer testing. The procedures for well development are presented in Subsection 4.4.6.5 of Volume I of the Fort Devens POP (ABB-ES, 1993d).

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Monitoring well development is documented on Well Development Field Data Records presented in Appendix E. Water was not added to the wells to aid in development.

### 5.5.8 In-Situ Hydraulic Conductivity Testing

In-situ hydraulic conductivity tests were performed on each of the six monitoring wells installed during the RI, in addition to the three 2446-series monitoring wells installed by ATEC in 1992, to obtain estimates of hydraulic conductivity. Appendix G presents data and analysis of the hydraulic conductivity testing. These tests generally consisted of falling and rising head tests within a given monitoring well. Falling head test data was analyzed for monitoring wells with static water levels above the top of the well screen. Rising head tests were performed on all monitoring wells except XJM-94-06X and XJM-94-10X, due to very slow ( $>2$  hours) water level recovery. The rate of water level recovery back to static conditions within the well casing was monitored using a pressure transducer and data logger. The elevation of the water level (for falling head tests) and depression (for rising head tests) was accomplished with a solid, cylindrical PVC slug using the techniques discussed in Subsection 4.8.2 of Volume I of the Fort Devens POP (ABB-ES, 1993d).

The data from all in-situ hydraulic conductivity tests were analyzed using the method of Bouwer and Rice (1976) with the Aqtesolv computer program. In addition, data were analyzed by the Hvorslev (1951) method. Discussion of the results of in-situ hydraulic conductivity testing are presented in Section 6.0 of this RI report.

### 5.5.9 Groundwater Sampling

Two rounds of groundwater samples (Rounds Five and Six) were collected from the six new and seven existing monitoring wells (see Figure 5-5). Round Five samples were collected in January 1995 and Round Six were collected in March 1995. The groundwater samples for these two rounds were submitted for laboratory analysis consisting of PAL VOCs, SVOCs, inorganics (both filtered and unfiltered), water quality parameters, and TSS (see Table 5-4). Groundwater sampling procedures are presented in Subsection 4.5.2.2 of Volume I of the Fort Devens POP (ABB-ES, 1993d). Field data records are presented in Appendix H,

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and off-site laboratory analytical results are discussed in detail in Section 7.0 of this report.

#### **5.5.10 Equipment Decontamination**

Several different sampling and analytical procedures were used during the AOC 43J RI field program, which led to a variety of decontamination procedures. Decontamination procedures were conducted in conformance with Subsection 4.3 in the Fort Devens POP (ABB-ES, 1993d). To document the effectiveness of decontamination procedures, periodic equipment rinsate blanks were collected and submitted for chemical analyses. Analytical results for the rinsate blanks are presented in Appendix D.

#### **5.5.11 Investigation-Derived Waste**

During the field program at the AOC 43J a variety of investigation-derived waste (IDW) was produced, including purge water, soil cuttings, well development water, decontamination fluids from the decontamination pad, grout, and personnel protective equipment. The collection, handling, and disposal of IDW was conducted in conformance with Subsection 4.10 of the Fort Devens POP (ABB-ES, 1993d).

#### **5.5.12 Location and Elevation Survey**

Upon completion of the field program at the AOC 43J, a location and elevation survey was conducted to accurately locate the explorations, including new and existing monitoring wells, piezometers, soil borings, screened auger explorations and TerraProbe™ points. A topographic survey was also conducted at the AOC 43J to better define the topographic features at the site.

The survey was conducted by Martinage Engineering, Inc. of Reading, MA. Horizontal control was established with a Leitz Sokkia II Total Station Vernier reading to one second accuracy. Vertical control was established using a Topcon Auto Level. Vertical locations were measured to within 0.01 feet and the horizontal control was measured as state planer coordinates to the nearest 0.1 feet.

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Monitoring wells and piezometers were surveyed for horizontal control and vertical control of the ground surface, top of the protective casing, and the top of the PVC well riser. Soil borings, screened auger explorations, and TerraProbe<sup>SM</sup> points were surveyed for horizontal control and vertical control. Procedures followed during the survey task are outlined in Subsection 4.9 of Volume I of the Fort Devens POP (ABB-ES, 1993d). Appendix I presents a summary of the survey data.

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WASTE OIL UST  
EXCAVATION

ONE-STORY  
WOODEN BLDG.  
T2448

STORAGE CONTAINERS

PAVED AREA

GASOLINE UST  
EXCAVATION

# LEGEND

- 2446-01
- SS-8
- SS-1/LRS-1
- LWS-1
- MONITORING WELL
- ATEC FIELD SCREENING (EXCAVATION)
- ATEC LABORATORY SOIL SAMPLE
- ATEC LABORATORY WATER SAMPLE
- CHAIN LINK FENCE WITH BARBED WIRE TOP

**FIGURE 5-2**  
**PREVIOUS CONTRACTOR EXPLORATIONS**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

0 15 30 60 FEET

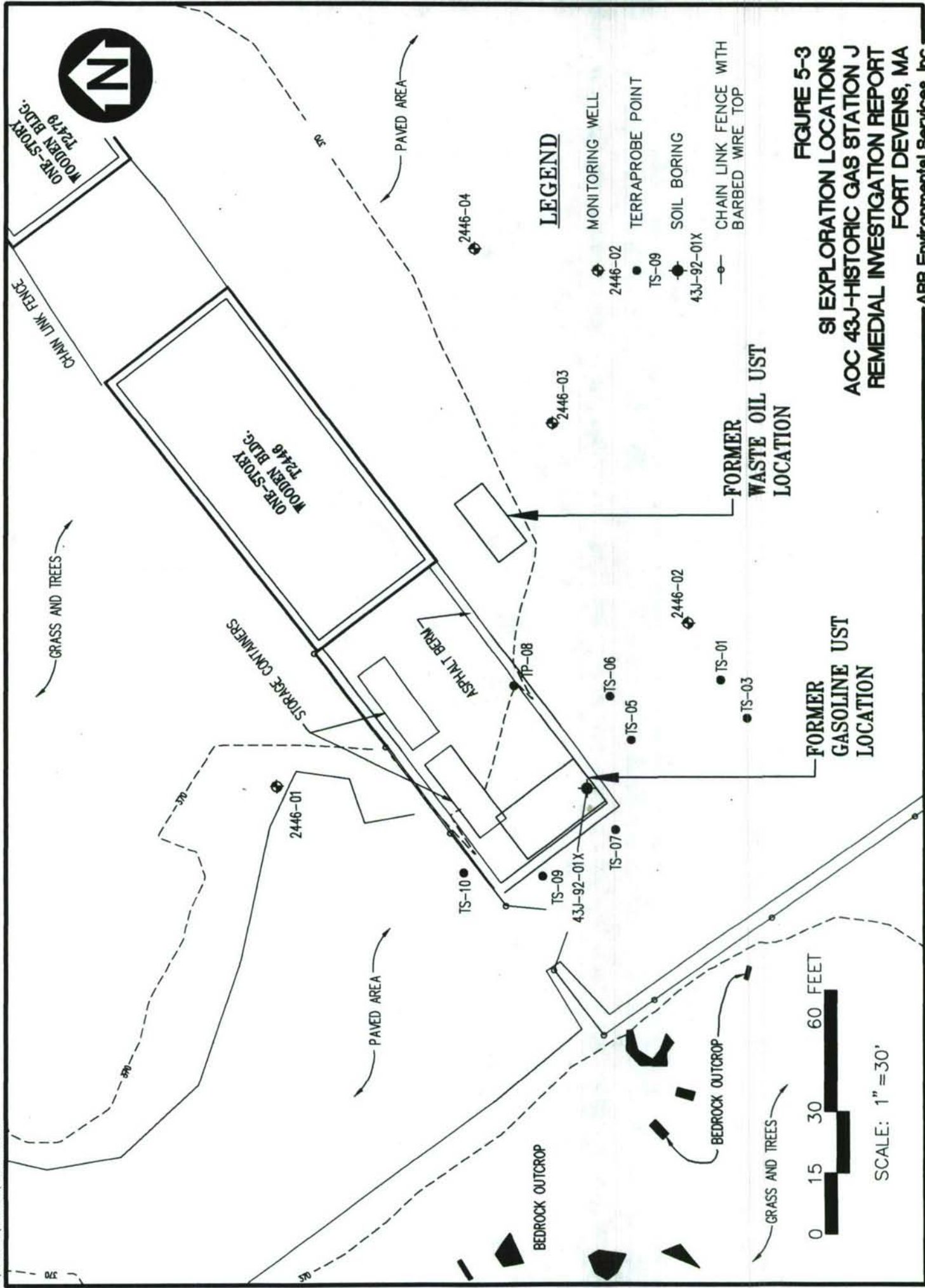
SCALE: 1" = 30'

BEDROCK OUTCROP

GRASS AND TREES











# **LEGEND**

MONITORING WELL

TERRAPROBE POINT

CHAIN LINK FENCE WITH  
BARBED WIRE TOP

2446-03

TS-11

—●—

CHAIN LINK FENCE

GRASS AND TREES

STORAGE CONTAINERS

ONE-STORY  
WOODEN BLDG.  
T2446

XJM-93-02X

PAVED AREA

PAVED AREA

BEDROCK OUTCROP

BEDROCK OUTCROP

GRASS AND TREES

0 15 30 60 FEET

SCALE: 1" = 30'

FORMER  
WASTE OIL UST  
LOCATION

FORMER  
GASOLINE UST  
LOCATION

ASPHALT BEAM

TS-18

TS-19

TS-24

TS-25

TS-27

TS-23

TS-26

TS-22

TS-21

TS-20

TS-14

TS-12

TS-13

TS-15

TS-16

TS-17

TS-11

TS-12

TS-13

TS-15

TS-16

TS-17

TS-18

TS-19

TS-24

TS-25

TS-27

FIGURE 5-4

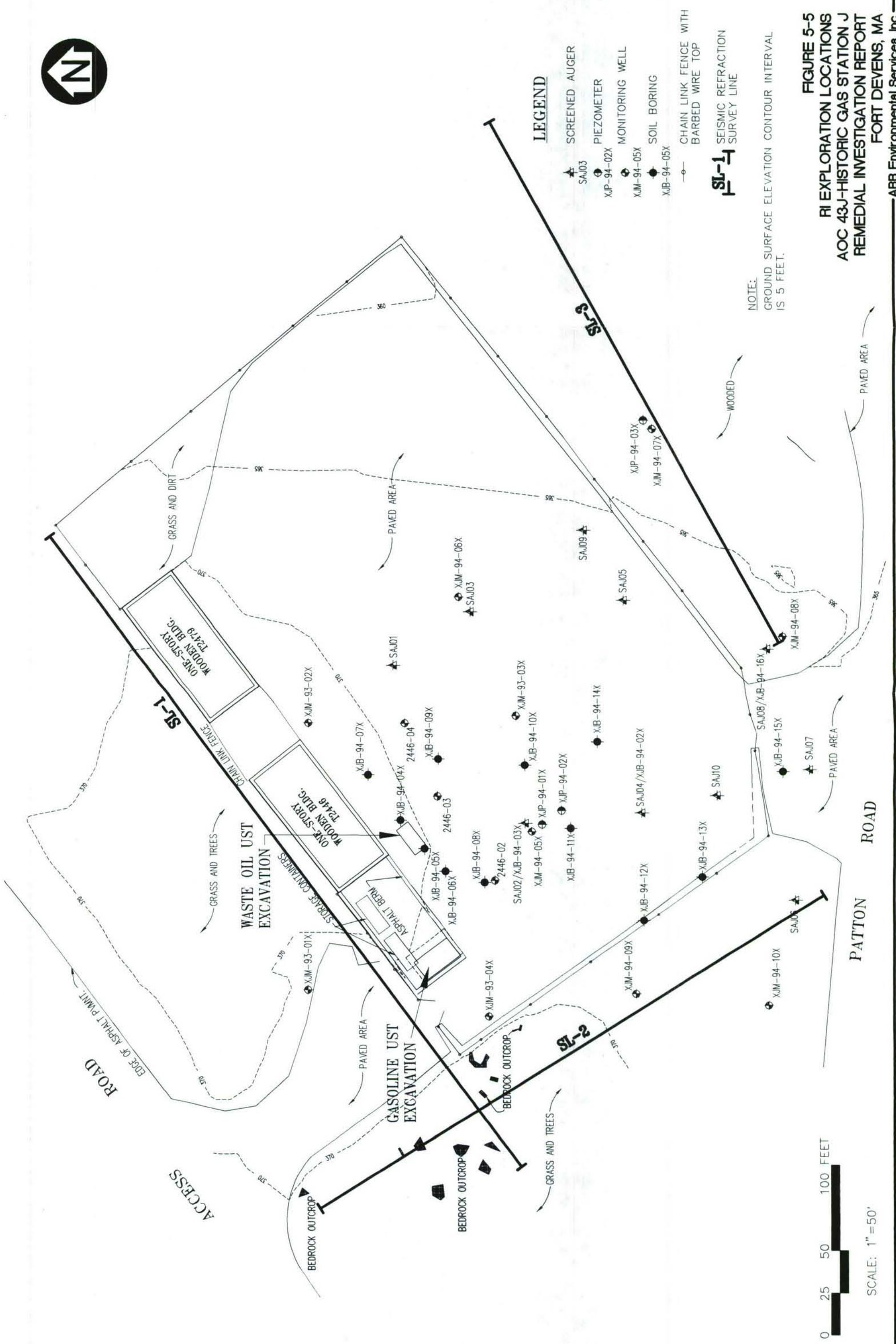
SSI EXPLORATION LOCATIONS  
AOC 43J-HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT

FORT DEVENS, MA

ABB Environmental Services, Inc.







**LEGEND**

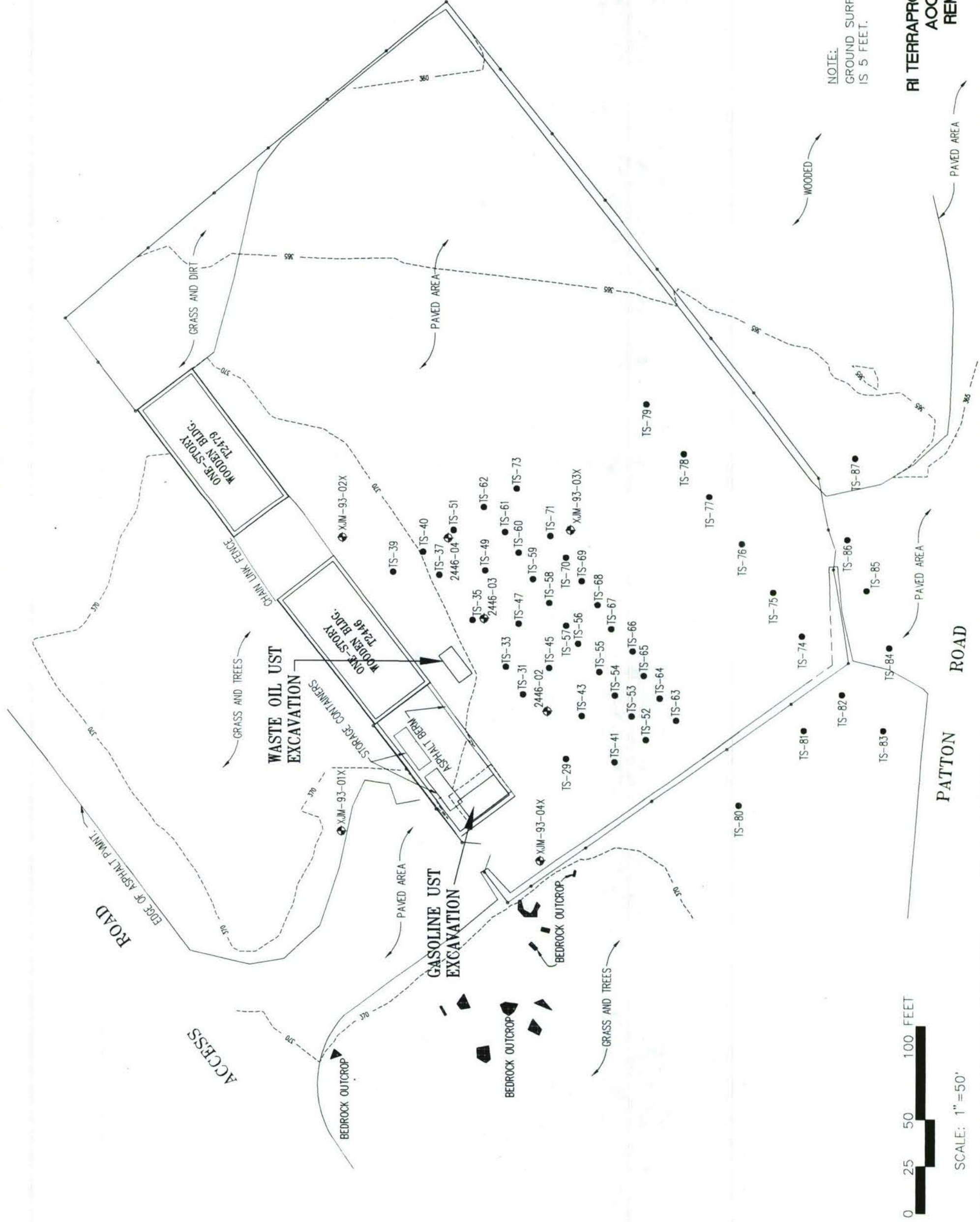
- SAJ03 SCREENED AUGER
- XJP-94-02X PIEZOMETER
- XJM-94-05X MONITORING WELL
- XJB-94-05X SOIL BORING
- CHAIN LINK FENCE WITH BARBED WIRE TOP
- SL-1 SEISMIC REFRACTION SURVEY LINE

NOTE:  
GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

**FIGURE 5-5**  
**RI EXPLORATION LOCATIONS**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**  
ABB Environmental Services, Inc.







**LEGEND**

- MONITORING WELL  
2446-01
- TERRAPROBE POINT  
TS-29
- CHAIN LINK FENCE WITH BARBED WIRE TOP

NOTE:  
GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

**FIGURE 5-6**  
**RI TERRAPROBE EXPLORATION LOCATIONS**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**  
**ABB Environmental Services, Inc.**





TABLE 5-1  
SUMMARY OF INVESTIGATION ACTIVITIES  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

MONTH/ YEAR	ACTIVITY	CONTRACTOR	NUMBER COMPLETED	EXPLORATION IDENTIFICATION	PURPOSE OF ACTIVITY
PREVIOUS CONTRACTOR INVESTIGATIONS					
MAY 1992	PULL 1,000-GAL WASTE OIL UST	ATEC	1 TANK	NA	REMOVE A POTENTIAL SOURCE OF SOIL AND GROUNDWATER CONTAMINATION
	SOIL SAMPLES	ATEC	10 SAMPLES	SS-1 TO SS-10	FIELD SCREENING SAMPLES TO ASSESS IMPACT TO SUBSURFACE SOIL FROM GASOLINE UST EXCAVATION PRIOR TO REMEDIATION.
			2 SAMPLES	LSS-1 TO LSS-2	LAB ANALYTICAL SAMPLES TO ASSESS IMPACT TO SUBSURFACE SOIL FROM GASOLINE UST EXCAVATION PRIOR TO REMEDIATION
AUGUST 1992	PULL 5,000-GAL GASOLINE UST	ATEC	1 TANK	NA	REMOVE A POTENTIAL SOURCE OF SOIL AND GROUNDWATER CONTAMINATION.
	SOIL SAMPLES	ATEC	8 SAMPLES	SS-1 TO SS-8	FIELD SCREENING SAMPLES TO ASSESS IMPACT TO SUBSURFACE SOIL FROM GASOLINE UST EXCAVATION PRIOR TO REMEDIATION.
			1 SAMPLE	LSS-1	LAB ANALYTICAL SAMPLE TO ASSESS IMPACT TO SUBSURFACE SOIL FROM GASOLINE UST EXCAVATION PRIOR TO REMEDIATION.
			4 SAMPLES	LRS-1 TO LRS-4	LAB ANALYTICAL AND FIELD SCREENING SAMPLES TO ASSESS IMPACT TO SUBSURFACE SOIL FROM GASOLINE UST EXCAVATION FOLLOWING REMEDIATION.
	GROUNDWATER SAMPLING	ATEC	1 SAMPLE	LWS-1	LAB ANALYTICAL SAMPLE TO ASSESS IMPACT TO GROUNDWATER FROM GASOLINE UST EXCAVATION FOLLOWING REMEDIATION.
OCTOBER 1992	MONITORING WELL INSTALLATION AND GROUNDWATER SAMPLING	ATEC	4 WELLS/4 SAMPLES	2446-01 TO 2446-04	WELL INSTALLATION AND GROUNDWATER SAMPLING TO ASSESS POTENTIAL IMPACT TO GROUNDWATER FROM FORMER WASTE OIL UST
SITE INVESTIGATION					
MAY 1992	GEOPHYSICS SURVEY	ABB-ES	1 SURVEY	NA	LOCATE 5,000 GALLON GASOLINE UST TO BE REMOVED BY ATEC.
SEPTEMBER 1992	TERRAPROBE POINTS	ABB-ES	8 POINTS	TS-01, TS-03, TS-05 TO TS-10	COLLECT SOIL SAMPLES FOR FIELD AND LABORATORY ANALYSIS AROUND FORMER GASOLINE UST
	SOIL BORINGS	ABB-ES	1 BORING	43J-92-01X	COLLECT SOIL SAMPLES FROM SOIL BORING NEAR FORMER GASOLINE UST FOR LABORATORY ANALYSIS
SUPPLEMENTARY SITE INVESTIGATION					
AUGUST 1993	TERRAPROBE POINTS	ABB-ES	15 POINTS	TS-11 TO TS-14 TS-16 TO TS-20 TS-22 TO TS-27	COLLECT SOIL SAMPLES NEAR FORMER WASTE OIL UST FOR FIELD ANALYSIS
	SOIL BORINGS AND MONITORING WELLS	ABB-ES	4 WELLS	XJM-93-01X TO XJM-93-04X	COLLECT SUBSURFACE SOIL SAMPLES FOR ANALYSIS AND INSTALL MONITORING WELLS TO ASSESS IMPACT TO GROUNDWATER FROM FORMER USTS
OCTOBER 1993	GROUNDWATER SAMPLING	ABB-ES	7 WELLS/SAMPLES	2446-02 TO 2446-04 XJM-93-01X TO XJM-93-04X	GROUNDWATER SAMPLING TO ASSESS POTENTIAL IMPACT TO GROUNDWATER FROM FORMER USTS
	INSITU HYDRAULIC CONDUCTIVITY TESTING		4 WELLS	XJM-93-01X TO XJM-93-04X	PERMEABILITY TESTING TO ESTIMATE AQUIFER HYDRAULIC CONDUCTIVITIES
JANUARY 1994	GROUNDWATER SAMPLING	ABB-ES	7 WELLS	2446-02 TO 2446-04 XJM-93-01X TO XJM-94-04X	GROUNDWATER SAMPLING TO ASSESS POTENTIAL IMPACT TO GROUNDWATER FROM FORMER USTS





TABLE 5-1  
SUMMARY OF INVESTIGATION ACTIVITIES  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

MONTH/ YEAR	ACTIVITY	CONTRACTOR	NUMBER COMPLETED	EXPLORATION IDENTIFICATION	PURPOSE OF ACTIVITY
REMEDIAL INVESTIGATION					
AUGUST 1994	GEOPHYSICAL SURVEY	ABB-ES	1 SURVEY	NA	LOCATE SAFE DRILLING LOCATIONS USING GPR
SEPTEMBER 1994	TERRAPROBE POINTS	ABB-ES	37 POINTS	TS-29, 31, 33, 35, 37, 39, 40, 41, 43, 45, 47, 49, AND TS-51 TO TS-54 TS-56 TO TS-71 TP-73 TO TP-80 TS-81 TO TS-83 TS-87	COLLECT SOIL SAMPLES NEAR FORMER USTS FOR FIELD ANALYSIS
SEPTEMBER/ OCTOBER 1994	SOIL BORINGS	ABB-ES	15 BORINGS	XJB-94-02X TO XJB-94-16X	COLLECT SOIL SAMPLES NEAR FORMER USTS FOR CONFIRMATION OF FIELD ANALYSES
OCTOBER 1994	SCREENED AUGERS	ABB-ES	10 EXPLORATIONS	SAJ01 TO SAJ10	COLLECT GROUNDWATER SAMPLES NEAR FORMER USTS FOR FIELD ANALYSIS
OCTOBER/ NOVEMBER 1994	MONITORING WELL INSTALLATION	ABB-ES	6 WELLS	XJM-94-05X TO XJM-94-10X	INSTALL MONITORING WELLS TO ASSESS IMPACT TO GROUNDWATER FROM FORMER USTS
NOVEMBER 1994	PIEZOMETER INSTALLATION	ABB-ES	2 PIEZOMETERS	XJP-94-01X AND XJP-94-02X	INSTALL PIEZOMETERS TO MONITOR GROUNDWATER LEVELS
NOVEMBER/ DECEMBER 1994	GROUNDWATER SAMPLING	ABB-ES	13 WELLS/13 SAMPLES	2446-02 TO 2446-04 XJM-93-01X TO XJM-93-04X XJM-94-05X TO XJM-94-10X	GROUNDWATER SAMPLING TO ASSESS POTENTIAL IMPACT TO GROUNDWATER FROM FORMER USTS
DECEMBER 1994	GEOPHYSICAL SURVEY	ABB-ES	1 SURVEY	NA	SEISMIC REFRACTION SURVEY TO FURTHER DEFINE THE BEDROCK SURFACE
FEBRUARY 1995	INSITU HYDRAULIC CONDUCTIVITY TESTING	ABB-ES	11 WELLS 1 PIEZOMETER	XJM-94-05X TO XJM-94-10X XJP-94-01X TO XJP-94-02X 2446-02 TO 2446-04	PERMEABILITY TESTING TO ESTIMATE AQUIFER HYDRAULIC CONDUCTIVITIES
MARCH 1995	GROUNDWATER SAMPLING	ABB-ES	13 WELLS/13 SAMPLES	2446-02 TO 2446-04 XJM-93-01X TO XJM-93-04X XJM-94-05X TO XJM-94-10X	GROUNDWATER SAMPLING TO ASSESS POTENTIAL IMPACT TO GROUNDWATER FROM FORMER USTS





TABLE 5-2  
SUMMARY OF ANALYTICAL PROGRAM  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION ID	DEPTH	ROUND	PARAMETERS													FIELD ANALYTICAL			
						OFF-SITE LABORATORY- PAL ANALYSES																
						VOC	SVOC	INOR-tot	INOR-dis	TCLP Metals	TPHC	H2O QUAL	TSS	TOC	BTEX	CHLOR	PID/TPHC/IR					
Waste Oil UST Removal	Soil	Excavation	SS-1															X				
			SS-2															X				
			SS-3															X				
			SS-4															X				
			SS-5															X				
			SS-6															X				
			SS-7															X				
			SS-8															X				
			SS-9															X				
			SS-10															X				
Historic Gas Station Gasoline UST Removal	Soil	Excavation	LSS-1							X								X				
			LSS-2									X							X			
			SS-1																X			
			SS-2																X			
			SS-3																X			
			SS-4																X			
			SS-5																X			
			SS-6																X			
			SS-7																X			
			SS-8																X			
SI	Water	Excavation	LRS-1															X				
			LRS-2															X				
			LRS-3															X				
			LRS-4															X				
			LSS-1															X				
			LWS-1															X				
			431-92-01X	5-7																		
			TS-01	8-9															X			
			TS-03	8-9															X			
			TS-05	3-4															X			
TS-06	8-9															X						
TS-07	3-4															X						
TS-08	8-9															X						
TS-09	3-4															X						
TS-10	3-4															X						





TABLE 5-2  
SUMMARY OF ANALYTICAL PROGRAM  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION ID	DEPTH	ROUND	PARAMETERS											FIELD ANALYTICAL		
						OFF-SITE LABORATORY- PAL ANALYSES					PARAMETERS						BTEX	CHLOR	PID/TPHC/IR
						VOC	SVOC	INOR-4et	INOR-dis	ICLP Metals	TPHC	H2O QUAL	TSS	TOC					
SSI	Soil	T_Probe	TS-11	8-9													X		X
			TS-12	8-9													X		X
			TS-13	8-9													X		X
			TS-14	8-9													X		X
			TS-16	8-9													X		X
			TS-17	8-9													X		X
			TS-17	9-11													X		X
			TS-18	8-9													X		X
			TS-19	8-9													X		X
			TS-20	8-9													X		X
			TS-22	8-9													X		X
			TS-23	8-9													X		X
			TS-24	8-9													X		X
			TS-25	8-9													X		X
			TS-26	8-9													X		X
			TS-27	8-9													X		X
	Water	Groundwater	2446-02		3	X	X	X			X								
			2446-02		4	X	X	X			X		X	X					
			2446-03		3	X	X	X			X		X	X					
			2446-03		4	X	X	X			X		X	X					
			2446-04		3	X	X	X			X		X	X					
			2446-04		4	X	X	X			X		X	X					
			XJM-93-01X	10-12										X					
			XJM-93-02X	5-7										X					
			XJM-93-02X	10-12										X					
			XJM-93-03X	15-17										X					
			XJM-93-01X		3	X	X												
			XJM-93-01X		4	X	X												
	Water	Groundwater	XJM-93-02X		3	X	X						X	X					
			XJM-93-02X		4	X	X						X	X					
			XJM-93-02X		3	X	X						X	X					
			XJM-93-02X		4	X	X						X	X					
	Water	Groundwater	XJM-93-03X		3	X	X						X	X					
			XJM-93-03X		4	X	X						X	X					
	Water	Groundwater	XJM-93-04X		3	X	X						X	X					
			XJM-93-04X		4	X	X						X	X					





TABLE 5-2  
SUMMARY OF ANALYTICAL PROGRAM  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION ID	DEPTH	ROUND	PARAMETERS										FIELD ANALYTICAL		
						OFF-SITE LABORATORY - PAL ANALYSES										BTEX	CHLOR	PID/TPH/CIR
						VOC	SVOC	INOR-tot	INOR-dlts	TCLP Metals	TPHC	H2O QUAL	TSS	TOC				
RI	Water	S_Auger	SAJ01	13-23												X	X	X
			SAJ02	15-25												X	X	X
			SAJ03	13-23												X	X	X
			SAJ04	11-21												X	X	X
			SAJ05	12-22												X	X	X
			SAJ06	13-23												X	X	X
			SAJ07	8-18												X	X	X
			SAJ08	7-17												X	X	X
			SAJ09	9-19												X	X	X
			SAJ10	13-23												X	X	X
	Soil	T_Probe	TS-31	7-9												X	X	X
			TS-31	9-11												X	X	X
			TS-33	7-9												X	X	X
			TS-33	9-11												X	X	X
			TS-35	7-9												X	X	X
			TS-37	7-9												X	X	X
			TS-37	9-11												X	X	X
			TS-39	7-9												X	X	X
			TS-39	9-11												X	X	X
			TS-40	7-9												X	X	X
			TS-40	9-11												X	X	X
			TS-41	7-9												X	X	X
			TS-43	7-9												X	X	X
			TS-43	9-11												X	X	X
			TS-45	7-9												X	X	X
			TS-45	9-11												X	X	X
			TS-47	7-9												X	X	X
			TS-47	9-11												X	X	X
			TS-49	7-9												X	X	X
			TS-51	7-9												X	X	X
			TS-51	9-11												X	X	X
			TS-52	7-9												X	X	X
			TS-52	9-11												X	X	X





TABLE 5-2  
SUMMARY OF ANALYTICAL PROGRAM  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION ID	DEPTH	ROUND	PARAMETERS										FIELD ANALYTICAL		
						OFF-SITE LABORATORY- PAL ANALYSES										BTEX	CHLOR	PID/TPH/CTR
						VOC	SVOC	INOR-tot	INOR-dis	TCLP Metals	TPHC	H2O QUAL	TSS	TOC				
RI (cont.)	Soil	T_Probe	TS-53	7-9												X	X	X
			TS-53	9-11												X	X	X
			TS-54	7-9												X	X	X
			TS-54	9-11												X	X	X
			TS-55	7-9												X	X	X
			TS-55	9-11												X	X	X
			TS-56	7-9												X	X	X
			TS-56	9-11												X	X	X
			TS-57	7-9												X	X	X
			TS-57	9-11												X	X	X
			TS-58	7-9												X	X	X
			TS-58	9-11												X	X	X
			TS-59	7-9												X	X	X
			TS-59	9-11												X	X	X
			TS-60	7-9												X	X	X
			TS-60	9-11												X	X	X
			TS-61	7-9												X	X	X
			TS-61	9-11												X	X	X
			TS-62	7-9												X	X	X
			TS-63	7-9												X	X	X
			TS-63	9-11												X	X	X
			TS-64	7-9												X	X	X
			TS-64	9-11												X	X	X
			TS-65	7-9												X	X	X
			TS-66	7-9												X	X	X
			TS-66	9-11												X	X	X
			TS-67	7-9												X	X	X
			TS-67	9-11												X	X	X
			TS-68	7-9												X	X	X
			TS-68	9-11												X	X	X
			TS-69	7-9												X	X	X
			TS-69	9-11												X	X	X
			TS-70	7-9												X	X	X
			TS-70	9-11												X	X	X
			TS-71	7-9												X	X	X





TABLE 5-2  
SUMMARY OF ANALYTICAL PROGRAM  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION ID	DEPTH	ROUND	PARAMETERS										FIELD ANALYTICAL		
						OFF-SITE LABORATORY - PAL ANALYSES										BTEX	CHLOR	PID/TPHC/IR
						VOC	SVOC	INOR-tot	INOR-dis	TCPLP Metals	TPHC	H2O QUAL	TSS	TOC				
			TS-73	7-9											X	X	X	
			TS-73	9-11											X	X	X	
			TS-74	7-9											X	X	X	
			TS-74	9-11											X	X	X	
			TS-74	9-11											X	X	X	
			TS-75	7-9											X	X	X	
			TS-75	9-11											X	X	X	
			TS-76	7-9											X	X	X	
			TS-76	9-11											X	X	X	
			TS-76	9-11											X	X	X	
			TS-77	7-9											X	X	X	
			TS-77	9-11											X	X	X	
			TS-78	7-9											X	X	X	
			TS-78	9-11											X	X	X	
			TS-79	7-9											X	X	X	
			TS-79	9-11											X	X	X	
			TS-81	5-7											X	X	X	
			TS-82	7-9											X	X	X	
			TS-82	9-11											X	X	X	
			TS-83	7-9											X	X	X	
			TS-83	9-11											X	X	X	
			TS-84	7-9											X	X	X	
			TS-84	9-11											X	X	X	
			TS-84	9-11											X	X	X	
			TS-85	7-9											X	X	X	
			TS-85	9-11											X	X	X	
			TS-85	9-11											X	X	X	
			TS-86	7-9											X	X	X	
			TS-86	9-11											X	X	X	
			TS-86	9-11											X	X	X	
			TS-87	7-9											X	X	X	
			TS-87	9-11											X	X	X	
		Boring	XJB-94-02X	5-7										X	X	X	X	
			XJB-94-02X	7-9										X	X	X	X	
			XJB-94-02X	9-11										X	X	X	X	





TABLE 5-2  
SUMMARY OF ANALYTICAL PROGRAM  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION ID	DEPTH	ROUND	PARAMETERS										FIELD ANALYTICAL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
						OFF-SITE LABORATORY - PAL ANALYSES										BTX	CHLOR	PID/TPHC/TR																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
						VOC	SVOC	INOR-tot	INOR-dis	TCLP Metals	TPHC	H2O QUAL	TSS	TOC																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
RI (cont.)	Soil	Boring	XJB-94-03X XJB-94-03X XJB-94-03X XJB-94-03X XJB-94-03X XJB-94-04X XJB-94-04X XJB-94-04X XJB-94-04X XJB-94-05X XJB-94-05X XJB-94-05X XJB-94-05X XJB-94-05X XJB-94-05X XJB-94-05X XJB-94-06X XJB-94-06X XJB-94-06X XJB-94-06X XJB-94-07X XJB-94-07X XJB-94-07X XJB-94-07X XJB-94-08X XJB-94-08X XJB-94-08X XJB-94-09X XJB-94-09X XJB-94-09X XJB-94-10X XJB-94-10X XJB-94-10X	5-7 7-9 9-11 11-13 15-17 1-3 10-12 15-17 20-22 1-3 3-5 5-7 7-9 9-11 11-13 13-15 15-17 17-19 5-7 10-12 12-14 15-17 7-9 9-11 11-13 15-17 7-9 9-11 11-13 7-9 9-11 11-13 7-9 9-11 11-13 7-9 9-11 11-13																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											





TABLE 5-2  
SUMMARY OF ANALYTICAL PROGRAM  
AOC 43J - HISTORIC GAS STATION J

REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION ID	DEPTH	ROUND	PARAMETERS											
						OFF-SITE LABORATORY-PAL ANALYSES						FIELD ANALYTICAL					
						VOC	SVOC	INOR-404	INOR-diss	TCLP Metals	TPHC	H2O QUAL	TSS	TOC	BTEX	CHLOR	PID/TPHC/IR
RI (cont.)	Soil	Boring	XJB-94-10X	15-17		X	X								X	X	X
			XJB-94-10X	20-22		X	X	X							X	X	X
			XJB-94-11X	7-9		X	X	X							X	X	X
			XJB-94-11X	9-11		X	X								X	X	X
			XJB-94-11X	11-13		X	X	X							X	X	X
			XJB-94-11X	15-17		X	X								X	X	X
			XJB-94-12X	7-9		X	X	X							X	X	X
			XJB-94-12X	9-11		X	X	X							X	X	X
			XJB-94-12X	11-13		X	X	X							X	X	X
			XJB-94-13X	7-9		X	X	X							X	X	X
			XJB-94-13X	9-11		X	X	X							X	X	X
			XJB-94-13X	11-13		X	X	X							X	X	X
			XJB-94-13X	15-17		X	X	X							X	X	X
			XJB-94-14X	7-9		X	X								X	X	X
			XJB-94-14X	9-11		X	X								X	X	X
			XJB-94-14X	11-13		X	X	X							X	X	X
			XJB-94-14X	15-17		X	X	X							X	X	X
	Soil Soil Soil Soil Water	Boring Boring Boring Boring Groundwater	XJB-94-15X	7-9		X	X	X							X	X	X
			XJB-94-15X	9-11		X	X	X							X	X	X
			XJB-94-15X	11-13		X	X	X							X	X	X
			XJB-94-15X	15-17		X	X	X							X	X	X
			XJB-94-16X	7-9		X	X	X							X	X	X
			XJB-94-16X	20-22		X	X	X							X	X	X
			XJM-94-05X	10-12										X	X	X	X
			XJM-94-06X	10-12										X	X	X	X
			XJM-94-08X	15-17										X	X	X	X
			XJM-94-10X	15-17										X	X	X	X
			2446-02		5	X	X	X	X								
			2446-02		6	X	X	X	X								
			2446-03		5	X	X	X	X								
			2446-03		6	X	X	X	X								
			2446-04		5	X	X	X	X								
			2446-04		6	X	X	X	X								
			XJM-93-01X		5	X	X	X	X								
			XJM-93-01X		6	X	X	X	X								





TABLE 5-2  
SUMMARY OF ANALYTICAL PROGRAM  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

FIELD EVENT	MATRIX	SAMPLE TYPE	EXPLORATION ID	DEPTH	ROUND	PARAMETERS											
						OFF-SITE LABORATORY - PAL ANALYSES						FIELD ANALYTICAL					
RI (cont.)	Water	Groundwater				VOC	SVOC	INOR-det	INOR-dis	TCLP Metals	TPHC	H2O QUAL	TSS	TOC	BTEX	CHLOR	PID/TPHC/IR
			XJM-93-02X		5	X	X	X	X			X	X				
			XJM-93-02X		6	X	X	X	X			X	X				
			XJM-93-03X		5	X	X	X	X			X	X				
			XJM-93-03X		6	X	X	X	X			X	X				
			XJM-93-04X		5	X	X	X	X			X	X				
			XJM-93-04X		6	X	X	X	X			X	X				
			XJM-94-05X		5	X	X	X	X			X	X				
			XJM-94-05X		6	X	X	X	X			X	X				
			XJM-94-06X		5	X	X	X	X			X	X				
			XJM-94-06X		6	X	X	X	X			X	X				
			XJM-94-07X		5	X	X	X	X			X	X				
			XJM-94-07X		6	X	X	X	X			X	X				
			XJM-94-08X		5	X	X	X	X			X	X				
			XJM-94-08X		6	X	X	X	X			X	X				
			XJM-94-09X		5	X	X	X	X			X	X				
			XJM-94-09X		6	X	X	X	X			X	X				
			XJM-94-10X		5	X	X	X	X			X	X				
			XJM-94-10X		6	X	X	X	X			X	X				

Notes:

- VOA = Volatile Organic Analysis  
SVOA = Semivolatile Organic Analysis  
P/P = Pesticide/PCBs  
Inorg = Inorganics  
TOC = Total Organic Carbon  
EX = Explosives  
TSS = Total Suspended Solids  
tot = unfiltered  
dis = filtered  
PAL = Project Analyte List
- TDS = Total Dissolved Solids  
TPHC = Total Petroleum Hydrocarbons  
H2O QUAL = Sulfate, Alkalinity, Phosphate, Nitrite as Nitrogen, Total Kjeldhal Nitrogen  
BTEX = Benzene, Toluene, ethylbenzene, M/P/O-Xylenes  
CHLOR = Chlorinated VOCs  
TPHC/IR = Total Petroleum Hydrocarbons by Infrared Spectrophotometry  
X\* = Chlorinated VOCs without Vinyl Chloride  
\* = Lead only  
TCLP = Toxic Compound Leaching Procedure





**TABLE 5-3**  
**ATEC FIELD SCREENING/LABORATORY RESULTS - 1,000 GALLON UST**  
**AOC 43J - HISTORIC GAS STATIONS J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

SAMPLE NO.	FIELD SCREENING		LABORATORY	
	PID (ppm)	NDIR (ppm)	VOC (ppm)	TPH (ppm)
<u>SOIL</u>				
SS-1	8.4	39.3	N/A	N/A
SS-2	5.2	16.4	N/A	N/A
SS-3	8.2	12.8	N/A	N/A
SS-4	0.8	15.8	N/A	N/A
SS-5	16.8	213.8	N/A	N/A
SS-6	6.6	90.2	N/A	N/A
SS-7	0.0	20.5	N/A	N/A
SS-8	0.2	11.5	N/A	N/A
SS-9	5.6	864.9	N/A	N/A
SS-10	0.8	16.9	N/A	N/A
Stock-1	2.9	105.7	N/A	N/A
Stock-2	9.2	1,469.7	N/A	N/A
LSS-1	N/A	N/A	ND	74
LSS-2	N/A	N/A	ND	918
	<u>GROUNDWATER</u>			
2446-01	N/A	N/A	N/A	ND
2446-02	N/A	N/A	N/A	28
2446-03	N/A	N/A	N/A	140
2446-04	N/A	N/A	N/A	3

**NOTES:**

\* = total VOCs detected

SS = ATEC Field Screening Sample

LRS = ATEC Laboratory Remedial Soil Sample

LSS = ATEC Laboratory Soil Sample

LWS = ATEC Laboratory Water Sample (Water Sample from the Excavation)

Stock = Soil Stock Pile Sample

ND = Non-detect

N/A = Not applicable





**TABLE 5-4  
SUMMARY OF SOIL BORINGS  
AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA**

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE LABORATORY ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS) <sup>1</sup>	TOTAL VOCs BY PID (PPM)	COMMENTS
<b>PREVIOUS CONTRACTOR</b>						
2446-02	15	0-2 4-6 9-11		SP SW SM	60 60 100	
2446-03	18.8	0-2 4-6 9-11 14-16 18-18.8		SP SW SM ML ML	25 3 20 150 130	
2446-04	21	0-2 4-6 9-11 14-16 20-21		SP SW ML ML ML	BKG BKG BKG 20 1	
<b>SITE INVESTIGATION</b>						
43J-92-01X	6.2	5-6.2	5-6.2	SW	581	
<b>SUPPLEMENTARY SITE INVESTIGATION</b>						
XJM-93-01X	17	0-2 5-7 10-12 13-13.1	10-12	SP-SM SM SM-ML SM-SP	BKG BKG BKG BKG	Rollerbit bedrock from 13.1 to 17 feet
XJM-93-02X	17.5	0-2 5-7 10-12 14-16	5-7 10-12	SP SM SM SM	BKG BKG BKG BKG	
XJM-93-03X	18	1-3 5-7 10-12 15-16.4	15-16.4	SW SM SM SM	BKG BKG BKG BKG	
XJM-93-04X	15.2					No spoons collected Phyllite cored from 3.5 to 15.2 feet
<b>REMEDIAL INVESTIGATION</b>						
XJB-94-02X	11	5-7 7-9 9-11	5-7 7-9	SP SP SP	BKG 37.2 6.5	
XJB-94-03X	17	5-7 7-9 9-11 11-13 15-17	11-13 15-17	SP SP SP SM SM	BKG 168 487 1610 6.8	
XJB-94-04X	22.5	0.5-2.5 5-7 10-12 15-17 20-22	10-12 20-22	SP GW SM ML	BKG 0.4 2.4 BKG BKG	Asphalt to 0.5 feet bgs No Recovery
XJB-94-05X	18	1-3 3-5 5-7 7-9 9-11 11-13 13-15 15-17 17-18	5-7 15-17	SP SP SP SP SP-SM SP-SM SP-SM SM SM	BKG BKG BKG 2 500 120 12 7 11	





**TABLE 5-4  
SUMMARY OF SOIL BORINGS  
AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA**

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE LABORATORY ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS) <sup>1</sup>	TOTAL VOCs BY PID (PPM)	COMMENTS
XJB-94-06X	17.5	0.5-2.5 5-7 10-12 12-14 15-17	12-14 15-17	SP SW SM SM SP-SM	BKG BKG 8 500 10	
XJB-94-07X	21.5	7-9 9-11 11-13 15-17 20-21	9-11 11-13	SM SM SM-ML SM ML	BKG BKG BKG BKG BKG	
XJB-94-08X	12.5	7-9 9-11 11-12.5	7-9 9-11	ML-SM ML-SM SM-ML	720 1200 1600	
XJB-94-09X	20.5	7-9 9-11 11-13 15-17 20-20.4	7-9 9-11	SM-ML SM-ML SM-ML ML ML-SM	BKG 1.0 BKG BKG BKG	
XJB-94-10X	21.5	7-9 9-11 11-13 15-17 20-22	7-9 20-22	SM SM SP-ML ML-SM ML	90 820 80 12 1	
XJB-94-11X	18.5	7-9 9-11 11-13 15-17	7-9 11-13	SM-ML SM-ML ML SM-ML	400 1100 800 2	
XJB-94-12X	14.5	7-9 9-11 11-13	7-9 11-13	SP-SM ML-SM ML-SM	0 70 600	
XJB-94-13X	18.5	7-9 9-11 11-13 15-17	9-11 11-13	ML-SM ML-SM SM-ML	BKG BKG 3 BKG	Weathered Bedrock
XJB-94-14X	20	7-9 9-11 11-13 15-17	11-13	SP-SM ML-SM ML-SM ML	BKG BKG BKG BKG	
XJB-94-15X	21.5	7-9 9-11 11-13 15-17 20-21.5	7-9 15-17	SW ML-SM CL ML ML	BKG 27 BKG BKG BKG	
XJB-94-16X	27.5	7-9 9-11 15-17 20-22 25-27	7-9 20-22	SW ML ML ML ML	BKG BKG BKG BKG BKG	
XJM-94-05X	16.1	0.5-2.5 5.0-7.0 10-12 15-17		SW SW ML ML	5 275 686 413	Asphalt to 0.5 feet bgs  Boring completed to 16.1
XJM-94-06X	17	1-3 5-7 10-12 15-16		SW SW-SM ML ML	BKG BKG BKG BKG	Asphalt to 1.0 feet bgs  Boring completed to 17.0





**TABLE 5-4  
SUMMARY OF SOIL BORINGS  
AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA**

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	OFF-SITE LABORATORY ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS) <sup>1</sup>	TOTAL VOCs BY PID (PPM)	COMMENTS
XJM-94-07X	16.4	0-2		SM-SP	BKG	Boring completed to 16.4
XJM-94-08X	18	5-7		SM	BKG	
		0-2		SM	BKG	Boring completed to 18
		5-7		SW-SM	BKG	
		10-12		SM	BKG	
		15-17		SM	BKG	
XJM-94-09X	22	0-2		SM	BKG	No recovery, cobble in sampler
		5-7		SM-ML	BKG	
		10-12			BKG	
		15-17		ML	38	
		20-22		ML	23	
XJM-94-10X	22.5	0-2		SW	BKG	No recovery, cobble in sampler
		5-5.5			BKG	
		7-9		SW-ML	BKG	No recovery, cobble in sampler
		10-12			BKG	
		15-17		ML	BKG	
		20-22		ML	BKG	
		22-22.5		PHYL	BKG	
XJP-94-01X	16.5	0.5-2.5		SW	BKG	
		5.0-6.5		SW	4	
		10-12		ML	753	
		15-16.5		ML	115	
XJP-94-02X	17.2	0.5-2.5		SW	BKG	Asphalt to 0.5 feet bgs
		5-7		SW	BKG	Boring completed to 17.2
		10-12		ML	818	
		15-17		ML	4	
XJP-94-03X	58.7	0-2		SM	BKG	
		5-7		SW	BKG	No recovery, cobble in sampler
		10-12		ML	BKG	
		15-17		ML	BKG	
		20-22		ML	BKG	
		25-27		ML	BKG	
		30-30.9		ML	BKG	
		35-36.4			BKG	
		40-42		ML	BKG	
		45-47		ML	BKG	
		50-52		ML	BKG	
		55-57		ML	BKG	
		58.5-58.7		PHYL	BKG	

**NOTES:**

<sup>1</sup> USCS type determined from field sample by on-site geologist during sampling.

Soil classification made from grain size distribution analyses may vary from field classification.

bgs = below ground surface

BKG = Background levels of total VOCs, measured with a PID in the field

PHYL = phyllite

PID = Photoionization Detector

ppm = parts per million

USCS = Unified Soil Classification System

VOCs = Volatile Organic Compounds





**TABLE 5-5**  
**SUMMARY OF MONITORING WELL AND PIEZOMETER COMPLETION DETAILS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

WELL/PIEZOMETER IDENTIFICATION	SOIL DRILLING METHOD	BEDROCK DRILLING METHOD	MEDIA SCREENED	WELL SCREEN DEPTH (Feet bgs)	WELL SCREEN ELEVATION (Feet MSL)	COMPLETION DEPTH (Feet bgs)	CONSTRUCTION MATERIAL
<b>PREVIOUS CONTRACTOR:</b>							
2446-01	HOLLOW STEM AUGER	NA	SOIL	5.0-15.0	364.0-354.0	15.0	2" ID PVC
2446-02	HOLLOW STEM AUGER	NA	SOIL	8.0-18.0	361.5-351.5	18.8	2" ID PVC
2446-04	HOLLOW STEM AUGER	NA	SOIL	10.0-20.0	359.6-349.6	20.0	2" ID PVC
<b>SUPPLEMENTARY SITE INVESTIGATION</b>							
XJM-93-01X	HOLLOW STEM AUGER	ROLLER CONE	SOIL/BEDROCK	6.5-16.5	362.7 - 352.7	17.0	4" ID PVC
XJM-93-02X	HOLLOW STEM AUGER DRIVE AND WASH	NA	SOIL	5.9-15.9	365.2 - 355.2	17.5	4" ID PVC
XJM-93-03X	HOLLOW STEM AUGER	NA	SOIL	6.6-16.6	361.9 - 351.9	18.0	4" ID PVC
XJM-93-04X	NA	ROCK CORE/ OVER REAM	BEDROCK	4.5-14.5	364.2 - 354.2	15.2	4" ID PVC
<b>REMEDIAL INVESTIGATION</b>							
XJM-94-05X	HOLLOW STEM AUGER DRIVE AND WASH	NA	SOIL	6.1-16.1	362.8 - 352.8	16.1	4" ID PVC
XJM-94-06X	HOLLOW STEM AUGER DRIVE AND WASH	ROLLER CONE	SOIL/BEDROCK	6.7-16.7	361.2 - 351.2	17.0	4" ID PVC
XJM-94-07X	HOLLOW STEM AUGER DRIVE AND WASH	ROCK CORE/ OVER REAM	SOIL/BOULDER	3.7-13.7	358.5 - 348.5	16.4	4" ID PVC
XJM-94-08X	HOLLOW STEM AUGER	NA	SOIL	7.6-17.6	359.1 - 349.1	18.0	4" ID PVC
XJM-94-09X	HOLLOW STEM AUGER DRIVE AND WASH	NA	SOIL	8.7-18.7	360.3 - 350.3	22.0	4" ID PVC
XJM-94-10X	HOLLOW STEM AUGER DRIVE AND WASH	NA	SOIL	7.8-17.8	361.2 - 351.2	22.5	4" ID PVC
XJP-94-01X	HOLLOW STEM AUGER	NA	SOIL	6.2-16.2	362.6 - 352.6	16.5	1.5" ID PVC
XJP-94-02X	HOLLOW STEM AUGER	NA	SOIL	7.2-17.2	361.3 - 351.3	17.2	1.5" ID PVC

**Notes:**

\* Monitoring well 2446-01 has been destroyed

bgs = below ground surface

ID = Inside Diameter

MSL = Mean Sea Level

NA = Not Applicable

PVC = Polyvinyl Chloride

Drive and Wash = Boring advanced to refusal with hollow stem auger. 6-inch ID casing is then driven to or beyond refusal depth.

Boring is cleaned out with 5 7/8-inch OD roller cone and advanced into bedrock if so noted

Rock Core/Over Ream = Boring was advanced through bedrock by first coring with HQ 4-inch OD core barrel and then reaming out bedrock borehole with 5 7/8-inch OD roller cone to desired depth for installation of 4-inch ID monitoring well.





**TABLE 5-6**  
**ATEC FIELD SCREENING/LABORATORY RESULTS - 5,000 GALLON UST**  
**AOC 43J - HISTORIC GAS STATIONS J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

SAMPLE NO.	FIELD SCREENING		LABORATORY	
	PID (ppm)	NDIR (ppm)	VOC (ppm)	TPH (ppm)
SS-1	350	759.9	N/A	N/A
SS-2	400	315.6	N/A	N/A
SS-3	200	43.9	N/A	N/A
SS-4	150	189.5	N/A	N/A
SS-5	100	3122	N/A	N/A
SS-6	100	3534.8	N/A	N/A
SS-7	300	469.2	N/A	N/A
SS-8	290	659.8	N/A	N/A
LRS-1	6.0	N/A	N/A	38
LRS-2	7.0	N/A	N/A	ND
LRS-3	170.0	N/A	2.2*	N/A
LRS-4	180.0	N/A	N/A	2170
LSS-1	N/A	N/A	0.572	1660
LWS-1	N/A	N/A	0.132	114

**NOTES:**

\* = total VOCs detected

SS = ATEC Field Screening Sample

LRS = ATEC Laboratory Remedial Soil Sample

LSS = ATEC Laboratory Soil Sample

LWS = ATEC Laboratory Water Sample (Water Sample from the Excavation)

Stock = Soil Stock Pile Sample

ND = Non-detect

N/A = Not applicable





TABLE 5-7  
FIELD ANALYTICAL SUBSURFACE SOIL SAMPLES  
AOC 43J - HISTORIC GAS STATIONS J

REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE	TP-01 TSJ0105F 5 FT	TP-01 TSJ0109F 9 FT	TP-03 TSJ0309F 9 FT	TP-05 TSJ0504F 4 FT	TP-06 TSJ0609F 9 FT	TP-07 TSJ0704F 4 FT	TP-08 TSJ0809F 9 FT	TP-09 TSJ0904F 4 FT	TP-10 TSJ1004F 4 FT	TP-11 TSJ1109F 9 FT	TP-12 TSJ1209F 9 FT	TP-13 TSJ1309F 9 FT	TP-14 TSJ1409F 9 FT
ORGANICS													
BENZENE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 50
TOLUENE	710	770	17000	< 0.1	3400	< 0.1	< 0.1	< 0.1	< 0.1	4.1	< 0.1	< 0.1	1900
ETHYLBENZENE	3300	570	16000	< 0.1	15000	< 0.1	5400	< 0.1	< 0.1	8.7	< 0.1	< 0.1	1800
m/p-XYLENE	20000	2000	30000	< 0.1	29000	5300	13000	< 0.1	< 0.1	15	< 0.1	< 0.1	3200
p-XYLENE	10000	260	18000	< 0.1	11000	< 0.1	11000	< 0.1	< 0.1	5.6	< 0.1	< 0.1	520
OTHER													
TOTAL PETROLEUM HYDROCARBONS	NA	270	940	130	690	370	540	< 55	< 55	290	< 56	< 54	610

Notes:

< = Less than detection limit.

NA = Not analyzed





TABLE 5-7  
FIELD ANALYTICAL SUBSURFACE SOIL SAMPLES  
AOC 43J - HISTORIC GAS STATIONS J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE	TP-16	TP-17	TP-17	TP-17	TP-18	TP-19	TP-20	TP-22	TP-23	TP-24	TP-25	TP-26	TP-27
	TSJ1609F	TSJ1709F	TSJ1710F	TSJ1809F	TSJ1909F	TSJ2009F	TSJ2209F	TSJ2309F	TSJ2409F	TSJ2509F	TSJ2609F	TSJ2709F	TSJ2709F
ORGANICS	9 FT	9 FT	10 FT	9 FT	9 FT	9 FT	9 FT	9 FT	9 FT	9 FT	9 FT	9 FT	9 FT
BENZENE	<0.5	<0.1	<0.2	<0.1	<0.1	<0.3	<68	<14	<0.1	<130	<55	<0.6	<0.6
TOLUENE	<0.5	<0.1	31	<0.1	<0.1	77	<68	<14	<0.1	<130	<55	7.2	7.2
ETHYLBENZENE	<0.5	<0.1	83	<0.1	<0.1	490	<68	360	<0.1	2400	450	<0.6	<0.6
m/p-XYLENE	10	1.0	110	0.9	<0.1	970	1700	310	<0.1	6400	820	7.3	7.3
o-XYLENE	13	0.8	43	<0.1	<0.1	190	650	460	<0.1	3300	<55	7.1	7.1
OTHER													
TOTAL PETROLEUM HYDROCARBONS	<55	<53	<54	<55	<54	<55	110	280	<54	3100	<54	<55	<55

Notes:

< = Less than detection limit  
NA = Not analyzed





**TABLE 5-8**  
**ORGANIC ANALYTES IN SUBSURFACE SOIL**  
**AOC 43J - HISTORIC GAS STATIONS J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

ANALYTE	SSI					SI
	XJM-93-01X 10 FT	XJM-93-02X DUP 10 FT	XJM-93-02X 5 FT	XJM-93-02X 10 FT	XJM-93-03X 15 FT	43J-92-01X 5 FT
ORGANICS (ug/g)						
ACETONE	< 0.017	< 0.017	0.062	< 0.017	< 0.017	< 0.017
DI-N-BUTYL PHTHALATE	0.14	0.13	< 0.1	0.12	< 0.061	< 0.1
TRICHLOROFLUOROMETHANE	< 0.006	< 0.006	0.008	< 0.006	< 0.006	< 0.006
XYLENES	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.022
OTHER (ug/g)						
TOTAL ORGANIC CARBON	495	649	1050	< 360	3370	NA
TOTAL PETROLEUM HYDROCARBONS	< 28.5	< 28.8	220	< 28.5	< 28.5	1770

Notes:

< = Less than detection limit.





TABLE 5-9  
INORGANIC ANALYTES IN SUBSURFACE SOIL  
AOC 43J - HISTORIC GAS STATIONS J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE	BACKGROUND	SSI					SI	
		XJM-93-01X 10 FT	XJM-93-02X DUP 10 FT	XJM-93-02X 5 FT	XJM-93-02X 10 FT	XJM-93-03X 15 FT	43J-92-01X 5 FT	
INORGANICS (ug/g)								
ALUMINUM	15000.0	9680	6060	13900	5180	9220	NA	
ARSENIC	21.0	15	15	28	13	17	NA	
BARIUM	42.5	34	15.3	49	16.3	32.4	NA	
CADMIUM	2.0	< 0.7	1.1	< 0.7	< 0.7	< 0.7	NA	
CALCIUM	1400.0	1330	1350	1120	948	8940	NA	
CHROMIUM	31.0	18.3	21.6	55.4	19.6	19.8	NA	
COBALT	NA	6.67	7.73	12	8.08	8.68	NA	
COPPER	8.39	12.3	16.8	20.6	14.2	13.3	NA	
IRON	15000.0	15300	18300	25700	16700	17400	NA	
LEAD	36.9	6.9	12	11	9.8	6.5	10.9	
MAGNESIUM	5600.0	3400	3480	8220	2750	4590	NA	
MANGANESE	300.0	276	494	425	532	322	NA	
NICKEL	14.0	22.5	30	43	27.7	29.7	NA	
POTASSIUM	1700.0	1460	481	2940	506	1410	NA	
SODIUM	131.0	362	354	422	311	431	NA	
VANADIUM	28.7	13.6	8.36	31.4	7.96	13.7	NA	
ZINC	35.3	37	38.9	52.3	36	42	NA	

Notes:  
< = Less than detection limit.  
Shaded values exceed background limit.





TABLE 5-10  
ANALYTES IN GROUNDWATER  
AOC 43 J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: (µg/L)	Fort Devens Background Concentrations	ATBC				ROUND 3				ROUND 4				ROUND 5			
		2446-01 2446-02 2446-03 2446-04				2446-02 2446-02 2446-02 2446-02				2446-02 2446-02 2446-02 2446-02				2446-03 2446-03 2446-03 2446-03			
		2446-01	2446-02	2446-03	2446-04	2446-02	2446-02	2446-02	2446-02	2446-02	2446-02	2446-02	2446-02	2446-03	2446-03	2446-03	2446-03
PAL CATIONS/ANIONS (µg/L)																	
Chloride	6870	NA	NA	NA	NA	24600	141	3.03	141	3.03	141	3.03	141	3.03	141	3.03	141
Phosphate	3.03	NA	NA	NA	NA	71.9	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Sulfate	10.5	NA	NA	NA	NA	144	24.7	199	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1
Aluminum	39.6	NA	NA	NA	NA	57100	51100	51100	51100	51100	51100	51100	51100	51100	51100	51100	51100
Antimony	14700	NA	NA	NA	NA	44.5	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02
Arsenic	25	NA	NA	NA	NA	36.5	25	25	25	25	25	25	25	25	25	25	25
Barium	8.09	NA	NA	NA	NA	49.5	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09
Beryllium	9100	NA	NA	NA	NA	58800	15600	15600	15600	15600	15600	15600	15600	15600	15600	15600	15600
Bismuth	4.25	NA	NA	NA	NA	44.6	8.57	8.57	8.57	8.57	8.57	8.57	8.57	8.57	8.57	8.57	8.57
Boron	3480	NA	NA	NA	NA	18600	9650	9650	9650	9650	9650	9650	9650	9650	9650	9650	9650
Bromine	291	NA	NA	NA	NA	17200	15300	15300	15300	15300	15300	15300	15300	15300	15300	15300	15300
Calcium	34.3	NA	NA	NA	NA	90.9	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3
Chromium	2370	NA	NA	NA	NA	6940	2280	2280	2280	2280	2280	2280	2280	2280	2280	2280	2280
Cobalt	10800	NA	NA	NA	NA	36100	34200	34200	34200	34200	34200	34200	34200	34200	34200	34200	34200
Copper	11	NA	NA	NA	NA	39.7	11	11	11	11	11	11	11	11	11	11	11
Iron	21.1	NA	NA	NA	NA	129	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5
Lead		NA	NA	NA	NA												
Magnesium		NA	NA	NA	NA												
Manganese		NA	NA	NA	NA												
Nickel		NA	NA	NA	NA												
Potassium		NA	NA	NA	NA												
Sodium		NA	NA	NA	NA												
Vanadium		NA	NA	NA	NA												
Zinc		NA	NA	NA	NA												
PAL SEMI-VOLATILE ORGANICS (µg/L)																	
1,2-dichlorobenzene		NA	NA	NA	NA	1.7	NA	NA	1.7	NA	NA	1.7	NA	NA	NA	NA	NA
1,4-dichlorobenzene		NA	NA	NA	NA	1.7	NA	NA	1.7	NA	NA	1.7	NA	NA	NA	NA	NA
2,4-dimethylphenol		NA	NA	NA	NA	5.8	NA	NA	5.8	NA	NA	5.8	NA	NA	NA	NA	NA
2-methylnaphthalene		NA	NA	NA	NA	50	NA	NA	50	NA	NA	50	NA	NA	NA	NA	NA
2-methylphenol / 2-cresol		NA	NA	NA	NA	3.9	NA	NA	3.9	NA	NA	3.9	NA	NA	NA	NA	NA
4-methylphenol / 4-cresol		NA	NA	NA	NA	0.52	NA	NA	0.52	NA	NA	0.52	NA	NA	NA	NA	NA
Bis (2-ethylhexyl) Phthalate		NA	NA	NA	NA	100	NA	NA	100	NA	NA	100	NA	NA	NA	NA	NA
Naphthalene		NA	NA	NA	NA	200	NA	NA	200	NA	NA	200	NA	NA	NA	NA	NA
Phenanthrene		NA	NA	NA	NA	0.5	NA	NA	0.5	NA	NA	0.5	NA	NA	NA	NA	NA
PAL VOLATILE ORGANICS (µg/L)																	
1,2-dichloroethenes (cis And Trans Isomers)		NA	NA	NA	NA	50	NA	NA	50	NA	NA	50	NA	NA	NA	NA	NA
Xylenes		NA	NA	NA	NA	9000	NA	NA	9000	NA	NA	9000	NA	NA	NA	NA	NA
1,2-dichloroethane		NA	NA	NA	NA	50	NA	NA	50	NA	NA	50	NA	NA	NA	NA	NA
Acetone		NA	NA	NA	NA	50	NA	NA	50	NA	NA	50	NA	NA	NA	NA	NA
Benzene		NA	NA	NA	NA	200	NA	NA	200	NA	NA	200	NA	NA	NA	NA	NA
Carbon Tetrachloride		NA	NA	NA	NA	60	NA	NA	60	NA	NA	60	NA	NA	NA	NA	NA
Chloroform		NA	NA	NA	NA	50	NA	NA	50	NA	NA	50	NA	NA	NA	NA	NA
Ethylbenzene		NA	NA	NA	NA	3000	NA	NA	3000	NA	NA	3000	NA	NA	NA	NA	NA
Methylene Chloride		NA	NA	NA	NA	200	NA	NA	200	NA	NA	200	NA	NA	NA	NA	NA
Toluene		NA	NA	NA	NA	6000	NA	NA	6000	NA	NA	6000	NA	NA	NA	NA	NA
PAL WATER QUALITY PARAMETERS (µg/L)																	
Alkalinity		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrite, Nitrate - non Specific		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen By Kjeldahl Method		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Dissolved Solids		NA	NA	NA	NA	320000	NA	NA	320000	NA	NA	320000	NA	NA	NA	NA	NA
Total Hardness		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Suspended Solids		NA	NA	NA	NA	1700000	NA	NA	1700000	NA	NA	1700000	NA	NA	NA	NA	NA
OTHER (µg/L)																	
Total Petroleum Hydrocarbons		NID	28	140	3	6270	NA	NA	9000	NA	NA	34500	55000	NA	NA	NA	NA





TABLE 5-10  
ANALYTES IN GROUNDWATER  
AOC 43 J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number:	ROUND 4		ROUND 3		ROUND 4		ROUND 3	
	2446-03 01/27/94 13 MX4603X2	2446-03 01/27/94 13 MX4603X2	2446-04 01/27/94 15 MX4604X1	2446-04 01/27/94 15 MX4604X1	2446-04 01/27/94 15 MX4604X2	2446-04 01/27/94 15 MX4604X2	2446-04 01/27/94 15 MX4604X2	2446-04 01/27/94 15 MX4604X2
PAL CATIONS/ANIONS (µg/L)								
Chloride	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA
PAL METALS (µg/L)								
Aluminum	6870	8480	17500	141	65600	95100	141	141
Antimony	3.03	3.03	3.03	3.03	5.18	6.34	3.84	3.03
Arsenic	10.5	61.7	42.1	15.7	26.9	24.8	17.1	16.5
Barium	39.6	63	119	32.9	332	424	27.3	22.9
Calcium	14700	54000	64500	58100	89500	97300	57400	54000
Chromium	14.7	15.2	35.4	6.02	118	178	6.02	25.1
Cobalt	25	25	25	25	69.1	89	25	25
Copper	8.09	20.8	29.1	8.09	107	140	8.09	8.09
Iron	9100	31600	35900	1820	134000	191000	4280	4820
Lead	4.25	23.5	13.9	1.26	63.8	35.2	1.26	1.26
Magnesium	3480	13100	20600	14600	43800	57700	14900	13700
Manganese	291	9900	4780	3580	7070	7680	4860	4780
Nickel	34.3	34.3	49.4	34.3	230	308	34.3	34.3
Potassium	2370	3630	7780	3250	13600	18400	2680	2040
Sodium	10800	45000	69000	66000	60000	62500	63800	59600
Vanadium	11	11	30.9	11	86.1	126	11	11
Zinc	21.1	117	65.3	21.1	272	375	21.1	21.1
PAL SEMIVOLATILE ORGANICS (µg/L)								
1,2-dichlorobenzene	1.7	1.7	2.8	NA	2.5	3.6	NA	NA
1,4-dichlorobenzene	1.7	1.7	1.7	NA	1.7	1.7	NA	NA
2,4-dimethylphenol	5.8	5.8	5.8	NA	5.8	5.8	NA	NA
2-methylnaphthalene	44	44	13	NA	13	22	NA	NA
2-methylphenol/2-cresol	3.9	3.9	3.9	NA	3.9	3.9	NA	NA
4-methylphenol/4-cresol	1.2	1.2	0.52	NA	0.52	0.52	NA	NA
Bis (2-ethylhexyl) Phthalate	6.9	6.9	100	NA	4.8	4.8	NA	NA
Naphthalene	100	100	60	NA	70	100	NA	NA
Phenanthrene	0.5	0.5	0.5	NA	0.5	0.5	NA	NA
PAL VOLATILE ORGANICS (µg/L)								
1,2-dichloroethylene (cis And Trans Isomers)	10	10	2	NA	10	20	NA	NA
xylene	2000	300	500	NA	1000	900	NA	NA
1,2-dichloroethane	300	10	2	NA	10	5	NA	NA
Acetone	10	10	60	NA	300	100	NA	NA
Benzene	50	50	30	NA	70	80	NA	NA
Carbon Tetrachloride	10	10	3	NA	10	6	NA	NA
Chloroform	10	10	2	NA	10	8	NA	NA
Ethylbenzene	2000	2000	300	NA	1000	1000	NA	NA
Methylene Chloride	60	60	10	NA	60	20	NA	NA
Toluene	1000	1000	200	NA	500	400	NA	NA
PAL WATER QUALITY PARAMETERS (µg/L)								
Alkalinity	NA	NA	NA	NA	NA	NA	NA	NA
Nitrite, Nitrate-non Specific	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen By Kjeldahl Method	NA	NA	NA	NA	NA	NA	NA	NA
Total Dissolved Solids	340000	NA	450000	NA	440000	440000	NA	NA
Total Hardness	NA	NA	NA	NA	NA	NA	NA	NA
Total Suspended Solids	700000	NA	1400000	NA	1200000	1200000	NA	NA
OTHER (µg/L)								
Total Petroleum Hydrocarbons	1100	NA	781	NA	670	200	NA	NA





TABLE 5-10  
ANALYTES IN GROUNDWATER  
AOC 43 J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number:	ROUND 3			ROUND 4			ROUND 3			ROUND 4		
	XJM-93-01X 10/04/93 11.5 MXXJ01X1	XJM-93-01X 10/04/93 11.5 MDD01X16	XJM-93-01X 02/02/94 11.5 MXXJ01X2	XJM-93-01X 02/02/94 11.5 MXXJ01X2	XJM-93-02X 10/07/93 10.9 MXXJ02X1	XJM-93-02X 12/02/94 10.9 MDXJ02X3	XJM-93-02X 10/07/93 10.9 MXXJ02X1	XJM-93-02X 12/02/94 10.9 MDXJ02X3	XJM-93-02X 01/25/94 10.9 MXXJ02X2	XJM-93-02X 01/25/94 10.9 MXXJ02X2	XJM-93-02X 01/25/94 10.9 MXXJ02X2	
	PAL CATIONS/ANIONS (µg/L)											
Chloride	NA	NA	NA	NA	NA	44000 D	NA	NA	NA	NA	NA	
Phosphate	NA	NA	NA	NA	NA	128 D	NA	NA	NA	NA	NA	
Sulfate	NA	NA	NA	NA	NA	10000 D	NA	NA	NA	NA	NA	
PAL METALS (µg/L)												
Aluminum	6870	141	141	14200	3910	4110 D	141	141	141	141	10600	
Antimony	3.03	3.03	3.03	3.03	3.03	3.03 D	2.86	2.86	3.03	3.03	3.03	
Arsenic	10.5	2.54	2.54	14	51.8	12.3 D	53.3	53.3	22.1	22.1	22.8	
Barium	39.6	15.6	19.4	74.5	37.7	26.2 D	14.8	14.8	9.72	10.2	63.5	
Calcium	14700	53500	58200	53900	34400	51300 D	33600	33600	46600	46600	45100	
Chromium	14.7	6.02	6.02	33.8	11.7	15.5 D	6.02	6.02	6.02	6.02	29.5	
Cobalt	25	25	25	25	25	25 D	25	25	25	25	25	
Copper	8.09	8.09	8.09	22.1	8.66	8.09 D	8.09	8.09	8.09	8.09	17.7	
Iron	9100	38.8	38.8	20500	24900	14000 D	19200	19200	15400	15400	28900	
Lead	4.25	1.26	1.26	20.1	5.1	5.1 D	1.26	1.26	1.26	1.26	9.76	
Magnesium	3480	11700	13700	15700	7650	9740 D	6840	6840	8880	8880	10400	
Manganese	291	49.5	52.5	890	7910	14600 D	7590	7590	11300	11300	9890	
Nickel	34.3	34.3	34.3	42.8	34.3	34.3 D	34.3	34.3	34.3	34.3	34.3	
Potassium	2370	5120	5720	5060	2460	3290 D	1710	1710	2450	2450	4010	
Sodium	10800	22400	22700	16800	28300	37900 D	28800	28800	40100	40100	32400	
Vanadium	11	11	12.4	18.2	12.2	11 D	11	11	11	11	12.8	
Zinc	21.1	21.1	21.1	62.7	24	34 D	21.1	21.1	21.1	21.1	115	
PAL SEMIVOLATILE ORGANICS (µg/L)												
1,2-dichlorobenzene	NA	NA	NA	1.7	2.6	8.1 D	NA	NA	NA	NA	7.7	
1,4-dichlorobenzene	NA	NA	NA	1.7	1.7	1.7 D	NA	NA	NA	NA	1.7	
2,4-dimethylphenol	NA	NA	NA	5.8	5.8	5.8 D	NA	NA	NA	NA	5.8	
2-methylnaphthalene	NA	NA	NA	1.7	1.7	1.7 D	NA	NA	NA	NA	2.9	
2-methylphenol / 2-cresol	NA	NA	NA	3.9	3.9	3.9 D	NA	NA	NA	NA	3.9	
4-methylphenol / 4-cresol	NA	NA	NA	0.52	0.52	0.52 D	NA	NA	NA	NA	0.52	
Bis (2-ethylhexyl) Phthalate	NA	NA	NA	4.8	4.8	8.4 D	NA	NA	NA	NA	4.8	
Naphthalene	NA	NA	NA	0.5	0.5	0.5 D	NA	NA	NA	NA	13	
Phenanthrene	NA	NA	NA	0.5	0.5	0.5 D	NA	NA	NA	NA	0.5	
PAL VOLATILE ORGANICS (µg/L)												
1,2-dichloroethenes (cis And Trans Isomers)	NA	NA	NA	0.5	0.5	0.5 D	NA	NA	NA	NA	2	
xylenes	NA	NA	NA	0.84	0.84	8 D	NA	NA	NA	NA	90	
1,2-dichloroethane	NA	NA	NA	0.5	0.5	0.5 D	NA	NA	NA	NA	2	
Acetone	NA	NA	NA	13	13	13 D	NA	NA	NA	NA	60	
Benzene	NA	NA	NA	0.5	0.5	0.5 D	NA	NA	NA	NA	20	
Carbon Tetrachloride	NA	NA	NA	0.58	0.58	0.58 D	NA	NA	NA	NA	3	
Chloroform	NA	NA	NA	0.5	0.5	0.5 D	NA	NA	NA	NA	2	
Ethylbenzene	NA	NA	NA	0.5	0.5	0.5 D	NA	NA	NA	NA	100	
Methylene Chloride	NA	NA	NA	2.3	2.3	2.3 D	NA	NA	NA	NA	10	
Toluene	NA	NA	NA	0.5	0.5	0.5 D	NA	NA	NA	NA	30	
PAL WATER QUALITY PARAMETERS (µg/L)												
Alkalinity	NA	NA	NA	NA	NA	203000 D	NA	NA	NA	NA	NA	
Nitrite, Nitrate - non Specific	NA	NA	NA	NA	NA	630 D	NA	NA	NA	NA	NA	
Nitrogen By Kjeldahl Method	NA	NA	NA	NA	NA	629 D	NA	NA	NA	NA	NA	
Total Dissolved Solids	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	240000	
Total Hardness	NA	NA	NA	NA	NA	192000 D	NA	NA	NA	NA	NA	
Total Suspended Solids	NA	NA	NA	770000	79000	110000 D	NA	NA	NA	NA	670000	
OTHER (µg/L)												
Total Petroleum Hydrocarbons	NA	NA	NA	190	180	180	NA	NA	NA	NA	190	





TABLE 5-10  
ANALYTES IN GROUNDWATER  
AOC 43 J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number:	ROUND 3		ROUND 4		ROUND 3		ROUND 4	
	XJM-93-03X 10/07/93 11.5 MXXJ03X1	XJM-93-03X 10/07/93 11.5 MXXJ03X1	XJM-93-03X 01/27/94 11.5 MXXJ03X2	XJM-93-03X 01/27/94 11.5 MXXJ03X2	XJM-93-04X 10/07/93 9.2 MXXJ04X1	XJM-93-04X 10/07/93 9.2 MXXJ04X1	XJM-93-04X 02/02/94 9.2 MXXJ04X2	XJM-93-04X 02/02/94 9.2 MXXJ04X2
<b>FAL CATIONS/ANIONS (µg/L)</b>								
Chloride	NA	NA	NA	NA	NA	NA	NA	NA
Phosphate	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA
<b>FAL METALS (µg/L)</b>								
Aluminum	6870	764	5260	141	41	141	150	141
Antimony	3.03	3.03	3.03	2.86	3.03	3.03	3.03	3.03
Arsenic	10.5	9.81	20	7.89	36.4	36.2	11.1	2.54
Barium	39.6	45.6	58	39.2	46.9	40.8	541	538
Bismuth	14700	66300	59900	62400	44800	44700	60900	58900
Chromium	14.7	6.02	13.5	6.02	6.02	6.02	6.02	6.02
Cobalt	25	25	25	25	25	25	25	25
Copper	8.09	8.09	11.5	8.09	8.09	8.09	8.43	8.09
Iron	9100	1360	10000	414	4690	5370	4660	3930
Lead	4.25	2.39	5.97	1.26	1.84	1.41	3.36	1.26
Magnesium	3480	18800	16200	15300	16000	15400	25200	25000
Manganese	291	60	2750	2580	3090	3430	2490	2540
Nickel	34.3	4.3	34.3	34.3	34.3	34.3	42.4	34.3
Potassium	2370	3450	4680	3520	10600	4350	4070	4250
Sodium	10800	78500	64600	66900	31800	23500	179000	188000
Vanadium	11	11	11	11	11	11	11	11
Zinc	21.1	24.3	33.7	21.1	21.1	21.1	114	117
<b>FAL SEMI-VOLATILE ORGANICS (µg/L)</b>								
1,2-dichlorobenzene	1.7	1.7	1.7	NA	1.7	NA	1.7	NA
1,4-dichlorobenzene	1.7	1.7	1.7	NA	1.7	NA	1.7	NA
2,4-dimethylphenol	5.8	NA	5.8	NA	5.8	NA	5.8	NA
2-methylnaphthalene	1.7	NA	4.5	NA	13	NA	5.4	NA
2-methylphenol / 2-cresol	3.9	NA	3.9	NA	3.9	NA	3.9	NA
4-methylphenol / 4-cresol	0.52	NA	0.52	NA	0.52	NA	1.2	NA
Bis (2-ethylhexyl) Phthalate	4.8	NA	4.9	NA	4.8	NA	4.8	NA
Naphthalene	0.5	NA	30	NA	60	NA	20	NA
Phenanthrene	0.5	NA	0.5	NA	0.5	NA	0.5	NA
<b>FAL VOLATILE ORGANICS (µg/L)</b>								
1,2-dichloroethenes (cis and trans isomers)	5	NA	2	NA	10	NA	5	NA
xylenes	800	NA	40	NA	1000	NA	400	NA
1,2-dichloroethane	5	NA	4	NA	10	NA	5	NA
Acetone	100	NA	100	NA	300	NA	200	NA
Benzene	200	NA	100	NA	70	NA	5	NA
Carbon Tetrachloride	6	NA	3	NA	10	NA	6	NA
Chloroform	20	NA	2	NA	10	NA	5	NA
Ethylbenzene	500	NA	100	NA	500	NA	100	NA
Methylene Chloride	20	NA	10	NA	60	NA	50	NA
Toluene	600	NA	100	NA	500	NA	100	NA
<b>FAL WATER QUALITY PARAMETERS (µg/L)</b>								
Alkalinity	NA	NA	NA	NA	NA	NA	NA	NA
Nitrite, Nitrate - non Specific	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen By Kjeldahl Method	NA	NA	NA	NA	NA	NA	NA	NA
Total Dissolved Solids	NA	430000	NA	NA	NA	NA	NA	NA
Total Hardness	NA	NA	NA	NA	NA	NA	NA	NA
Total Suspended Solids	42000	NA	340000	NA	9000	NA	21000	NA
<b>OTHER (µg/L)</b>								
Total Petroleum Hydrocarbons	1030	NA	210	NA	3350	NA	1700	NA





## 6.0 SITE HYDROLOGY, GEOLOGY AND GROUNDWATER CHARACTERIZATION

### 6.1 SITE HYDROLOGY

AOC 43J is located in the south-central portion of the Main Post on top of a topographic high. As a result, there are no surface water bodies (streams or ponds) in the immediate vicinity of the site. The area around the former USTs is paved, however, a large portion of the perimeter is unpaved. Based on topographic contours (Figure 6-1), precipitation runoff appears to be predominantly north to south and west to east across the site. Areas outside the fence and pavement appear to be well drained, with no indication of seasonal ponding or wetlands environment.

### 6.2 SITE GEOLOGY

This subsection presents geologic descriptions of the various formations encountered at AOC 43J, and an interpretation of the findings. Figure 6-1 presents the orientation of geologic cross sections. Figures 6-2 and 6-3 present geologic cross sections A-A' and B-B', respectively. Table 6-1 presents a summary of bedrock elevation data, and interpretive bedrock surface elevation contours are presented in Figure 6-4.

#### 6.2.1 Surficial Soils and Fill Material

Surficial soil at AOC 43J is classified by the SCS as the Hinckley-Freetown Windsor Association (see Figure 2-3) (SCS, 1991). Soils from this association in the immediate vicinity of AOC 43J were likely disturbed during construction of the paved motor pool area.

Based on the soil boring information collected at AOC 43J, it appears that fill soils were imported to level the original ground surface for construction of the motor pool area. Borings drilled at the site encountered fill soils ranging from 0.7 feet to 11 feet in thickness at XJM-93-04X (located adjacent to the bedrock outcrop) and XJB-94-07X (located approximately 30 feet outside of the

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motorpool's east fence), respectively. The fill thickness is relatively uniform beneath the site, except for the northwestern portion of the site where fill thickness decreases due to bedrock outcrops (see Subsection 6.2.3). These fill soils have variable colors (ranging from dark brown to light yellow brown to light olive gray), and textures (ranging from granular medium to coarse sands with subangular gravel to fine sand and silt). The fill soils are predominantly poorly graded, and medium dense to very dense.

### 6.2.2 Subsurface Soils

This subsection describes native subsurface soils found at AOC 43J below the surficial soil and fill material.

Soil borings drilled at AOC 43J encountered a glacial till beneath the surficial soils and fill material. Interpreted thickness of the till ranges from zero feet to 52 feet at XJM-93-04X and XJP-94-03X, respectively. Depth to till near the former gasoline and waste oil USTs is approximately 9 feet, with an average till thickness of 10 feet. The till consists of a poorly sorted fine sandy silt, silty sand, or clayey silt, with coarse sand, fine to medium gravel, and occasional angular siltstone fragments and cobbles. Grain-size test results presented in Appendix I support this description. The color of the till ranges from light olive brown to olive gray, with densities varying from loose to very dense.

One, or perhaps two, large siltstone boulders were encountered at boring XJM-94-07X (see Figure 6-1 and 6-2). The depth to the bottom of the second boulder or bedrock fragment was not determined. Boring XJP-94-03X was drilled approximately 7 feet northeast of XJM-94-07X, and did not encounter any boulders or bedrock until 58.5 feet bgs, supporting the presence of a boulder at XJM-94-07X. In addition, screened auger explorations SAJ05 and SAJ09 encountered auger refusal at 10 feet and 10.5 feet bgs, respectively. These elevations do not fit the interpreted bedrock surface elevation contours presented in Figure 6-4. Given the glacial geologic setting, the presence of large boulders is not unexpected.



### 6.2.3 Bedrock Geology

Bedrock in the vicinity of AOC 43J is classified as the Oakdale formation (Zen, 1983). The formation is described as fine-grained metasiltstone and phyllite, consisting of quartz, and minor feldspar and ankerite. The metasiltstone and phyllite is commonly deformed by kink banding. Bedrock coring performed at AOC 43J was performed only at monitoring well boring XJM-93-04X (see Figure 6-2). The boring log from this boring indicates a dark gray to olive gray phyllite with secondary quartz stringers, and weathered, silt/till-filled fractures (see Appendix A). Based on split-spoon samples and auger refusal, the bedrock surface at AOC 43J appears to be lightly to moderately weathered.

Visual observations at the site noted bedrock outcrops west and north of XJM-93-04X. Borings drilled at the site encountered bedrock from 0.7 feet to 58.5 feet bgs at XJM-93-04X and XJP-94-03X, respectively (see Table 6-1). The bedrock surface appears to dip to the southeast between these two borings (see Figure 6-2). The sloped bedrock surface between XJM-93-03X and XJP-94-03X may represent one side of a bedrock trough or depression. Subsection 6.2.2 presents a discussion of depth to bedrock in the vicinity of XJM-94-07X and XJP-94-03X. The average interpreted depth to bedrock is relatively uniform at 15 feet to 20 feet bgs from southwest to northeast across the site (see Figure 6-3). Figure 6-4 presents an interpretive bedrock surface elevation contour map. The bedrock surface presented in Figures 6-2, 6-3, and 6-4 is interpreted from boring logs indicating split-spoon and/or auger refusal.

### 6.2.4 Summary and Interpretation of Seismic Survey Results

The objective of the seismic refraction survey performed by GPRI at AOC 43J was to further define the bedrock surface. This subsection presents a summary of the findings of the survey. Complete details of the methodology and results of the survey, including interpretive profiles of depth to bedrock, are presented in Appendix B.

The following information was derived by GPRI from the results of the seismic refraction survey:

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- The surface of the bedrock could be distinguished on all of the refraction records.
- The seismic refraction survey showed that the overburden at the site is unsaturated to fully saturated beginning at approximately 9 feet bgs. The uppermost material has a velocity range of 1,000 to 1,700 feet per second, representative of unsaturated to slightly saturated silty sand and sand, and an intermediate layer with a range of 2,900 to 5,000 feet per second consisting of partially to fully saturated materials similar to the uppermost layer.
- The bedrock surface was shown to have moderately uniform slopes. The depth to bedrock ranges from zero to about 40 feet.
- Moderately competent to sound bedrock was detected on all profiles. The velocities of most of the bedrock, 15,000 to 19,000 feet per second, are indicative of a sound phyllitic bedrock, which is consistent with boring logs.
- One interval of moderately low bedrock velocity, 12,200 feet per second, was determined near SAJ06 and XJM-94-10X, indicative of more weathered bedrock than that profiled across the rest of the site.

In general, the depths to bedrock determined from the seismic survey are in relatively close ( $\pm 5$  feet) agreement with physical data obtained from borings at AOC 43J. However, the one major difference between the findings of the seismic refraction survey and the borehole geologic data is that the seismic data indicates that the bedrock surface is relatively flat between XJB-94-16X and XJP-94-03X/XJM-94-07X. However, Figure 6-4 indicates that the interpreted bedrock surface drops over 30 feet from XJB-94-16X to XJP-94-03X. The observed, relatively flat, bedrock profile in the seismic data may be a result of dense glacial till (lodgement till), numerous boulders (see Subsection 6.2.2) and/or spacing of geophones.

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### 6.2.5 Site Geology Interpretation Summary

The geology at AOC 43J can be classified in three different categories (from ground surface downward): surficial soil and fill, glacial till, and phyllite bedrock. The surficial soil and fill is composed of fine to coarse sands with subangular gravel, fine sand, and silt, and ranges in thickness from 0.7 to 11 feet across the site. The till ranges in thickness from zero to 52 feet from northwest to southeast across the site (see Figure 6-2 and 6-4). In all explorations, the till was overlain by fill. Large boulders were encountered in the till in the southeastern portion of the site at XJM-94-07X, and potentially at screened auger explorations SAJ05 and SAJ09. Bedrock encountered beneath AOC 43J is a lightly to moderately weathered, fine-grained metasilstone and phyllite. Near-surface fractures are filled with silt/till. Depth to bedrock ranges from zero feet bgs in the northwestern portion of the site (bedrock outcrop) to 58.5 feet bgs in the southeastern portion of the site. The relatively steep dip of the bedrock surface to the southeast may represent one side of a bedrock trough and appears to coincide with the regional geomorphology. This steep dip of the bedrock surface was not detected by the seismic refraction survey performed at AOC 43J due to geologic features (i.e., dense lodgment till) and potential geophone spacing.

### 6.3 HYDROGEOLOGY

This subsection presents data and interpretations of hydrogeologic conditions at AOC 43J. Groundwater levels used in this subsection are presented in Appendix F and summarized in Table 6-2, and interpretive water table elevation contours are presented in Figure 6-5 and 6-6. A summary of in-situ hydraulic conductivity test results is presented in Table 6-3, and Appendix G presents the results from each in-situ hydraulic test.

As a result of the type of contaminants (primarily fuel compounds) identified in groundwater at AOC 43J, all monitoring wells have been installed as water table wells (i.e., their well screen interval spans the water table) to assess the presence of floating site-related contaminants. All monitoring wells are screened in the till/fill, with the exception of XJM-93-01X which is screened across the till/bedrock interface, and XJM-93-04X which is screened entirely in bedrock.

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Given these conditions, the following discussion will focus on water table conditions in the till at AOC 43J.

The water table generally occurs in the till across AOC 43J, with the exception of the northwest corner of the site, where the water table is present in the bedrock (see Figures 6-2 and 6-3). Figure 6-5 and 6-6 present water table elevation contour maps for AOC 43J. Groundwater elevations presented on Figure 6-5 are from water level measurements collected on January 31, 1995, while Figure 6-6 shows contours based on water level measurements collected on May 9, 1995. Appendix F presents the water level data used for this assessment. Based on the data collected on January 31, 1995, groundwater appears to flow radially from the topographic high. The map indicates that groundwater flows predominantly toward the southeast across the southern portion of the site, and toward the east and northeast across the northern portion of the site. Horizontal gradients range from 0.031 feet/foot across the northern portion of the site to 0.017 feet/foot across the southern portion of the site.

Water level measurements collected on May 9, 1995 present a different groundwater flow direction (see Figure 6-6). Groundwater appears to flow radially from XJM-93-02X to the south and eventually to the southeast. Water level measurements were taken on November 8, 1993 from XJM-93-01X through XJM-93-04X (see SSI Data Package, ABB-ES 1994a) support the groundwater flow direction observed on January 31, 1995 (see Figure 6-5). Horizontal gradients calculated from May 9, 1995 water levels range from 0.009 to 0.036 feet/foot. The May 9, 1995 groundwater flow direction appears to be a seasonal condition.

In-situ hydraulic conductivity test results presented in Table 6-3 indicate horizontal hydraulic conductivity values for the till at AOC 43J range from  $2.9 \times 10^{-3}$  cm/sec to  $9.6 \times 10^{-7}$  cm/sec. Assuming an effective porosity of 30 percent, estimated groundwater flow velocities range from  $9 \times 10^{-5}$  feet/day to 0.6 feet/day. Appendix G presents detailed calculations for flow velocities and gradients.

In summary, the groundwater flow direction appears to vary with seasonal fluctuations in the water table elevations. The January 31, 1995 water table elevations indicated that groundwater flowed from the west-northwest to the east-southeast. However, the March 9, 1995 water table elevation showed a groundwater flow direction from the northern portion (XJM-93-02X) to the

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southeastern portion of the AOC (XJM-94-07X). This variation appears to be due to increased surface water recharge from areas north of AOC 43J. The moderately slow groundwater flow velocities are consistent with the types of soil (glacial till) observed at this AOC.

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ROAD

EDGE OF ASPHALT PAVT.

ACCESS

WASTE OIL UST  
EXCAVATION

STORAGE CONTAINERS

ONE-STOREY  
WOODEN BLDG.  
T2446

GASOLINE UST  
EXCAVATION

ASPHALT BERM

BEDROCK OUTCROP

BEDROCK OUTCROP

GRASS AND TREES

A-A'

WOODED

PATTON ROAD

SCALE: 1" = 50'

0 25 50 100 FEET

NOTE:

GROUND SURFACE ELEVATION CONTOUR INTERVAL  
IS 1 FOOT.

LEGEND

- PIEZOMETER  
XJP-94-01X
- MONITORING WELL  
XJM-94-05X
- SOIL BORING  
XJB-94-05X

A-A'

CROSS SECTION ORIENTATION

CHAIN LINK FENCE WITH  
BARBED WIRE TOP

FIGURE 6-1  
ORIENTATION OF GEOLOGIC CROSS SECTIONS A-A' AND B-B'  
AOC 43J-HISTORIC GAS STATION J  
REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MA  
ABB Environmental Services, Inc.











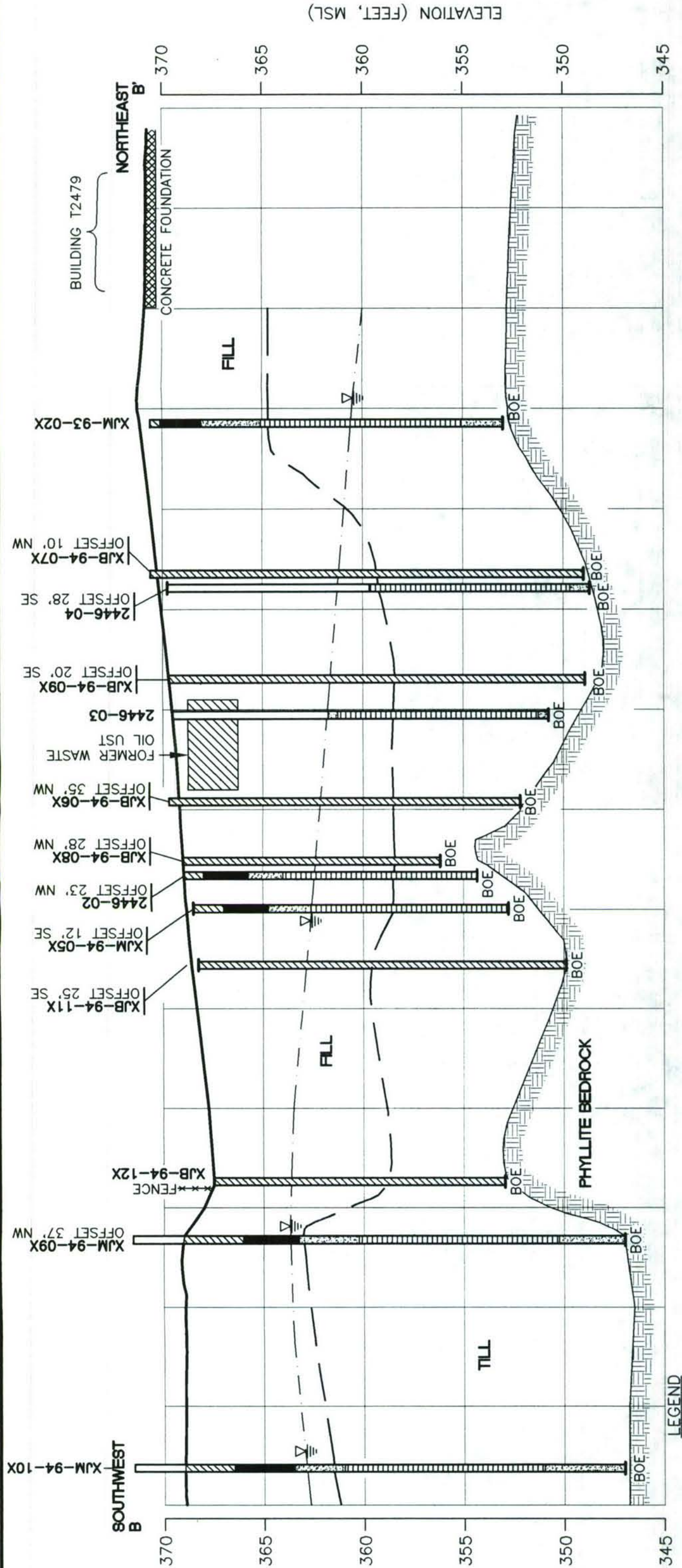




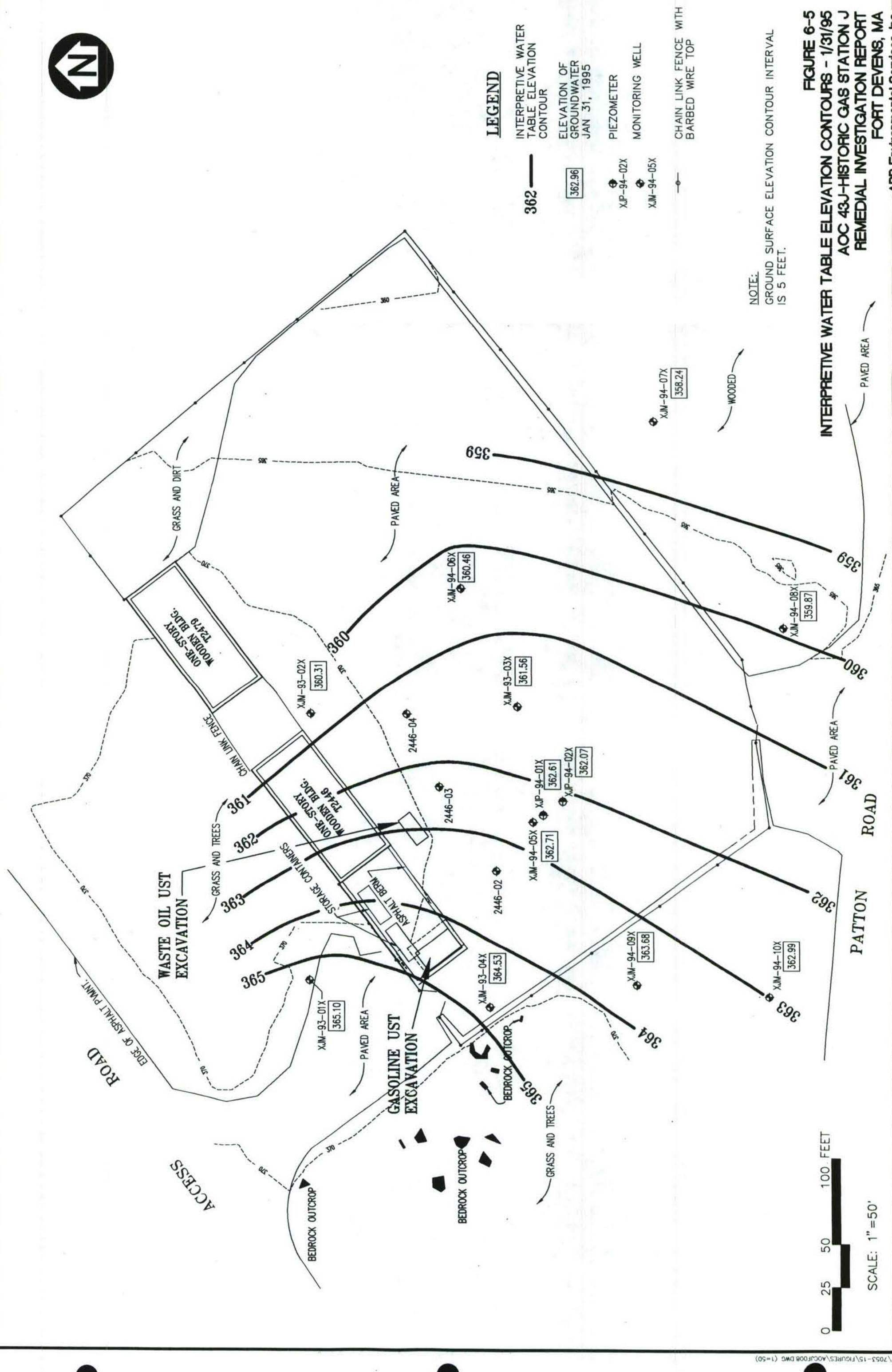




FIGURE 6-4  
INTERPRETIVE BEDROCK ELEVATION CONTOURS  
AOC 43J-HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA  
ABB Environmental Services, Inc.







**LEGEND**

- INTERPRETIVE WATER TABLE ELEVATION CONTOUR
- ELEVATION OF GROUNDWATER JAN 31, 1995
- PIEZOMETER
- MONITORING WELL
- CHAIN LINK FENCE WITH BARBED WIRE TOP

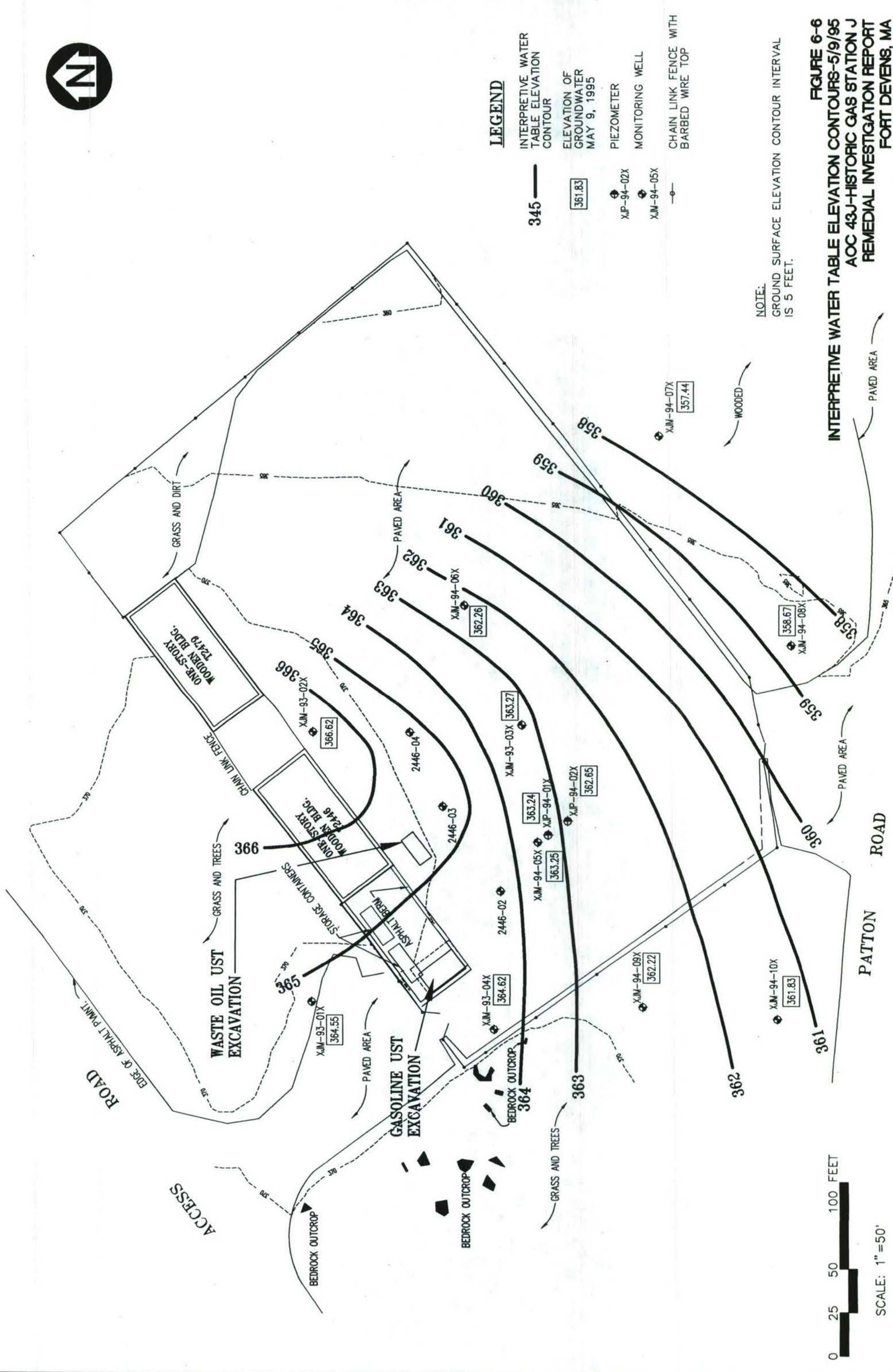
NOTE:  
GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

**FIGURE 6-5**  
**INTERPRETIVE WATER TABLE ELEVATION CONTOURS - 1/31/95**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**  
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0 25 50 100 FEET  
SCALE: 1"=50'







**LEGEND**

- INTERPRETIVE WATER TABLE ELEVATION CONTOUR
- ELEVATION OF GROUNDWATER MAY 9, 1995
- PIEZOMETER
- MONITORING WELL
- CHAIN LINK FENCE WITH BARBED WIRE TOP

NOTE:  
GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

**FIGURE 6-6**  
**INTERPRETIVE WATER TABLE ELEVATION CONTOURS-5/9/95**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
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**TABLE 6-1**  
**SUMMARY OF BEDROCK ELEVATION DATA**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

EXPLORATION TYPE	EXPLORATION ID	GROUND ELEVATION (Feet MSL)	DEPTH TO BEDROCK <sup>1</sup> (Feet bgs)	BEDROCK ELEVATION (Feet MSL)
<b>BORINGS</b>	43J-92-01X	369.4	6.2	363.2
	XJB-94-02X	367.56	NE	NA
	XJB-94-03X	368.9	17	351.9
	XJB-94-04X	370.3	22.5	347.8
	XJB-94-05X	370.1	18	352.1
	XJB-94-06X	369.7	17.5	352.2
	XJB-94-07X	370.5	21.5	349
	XJB-94-08X	369.2	12.5	356.7
	XJB-94-09X	369.4	20.5	348.9
	XJB-94-10X	368.8	21.5	347.3
	XJB-94-11X	368.4	18.5	349.9
	XJB-94-12X	367.5	14.5	353
	XJB-94-13X	367.1	18.5	348.6
	XJB-94-14X	368	20	348
	XJB-94-15X	366.1	21.5	344.6
	XJB-94-16X	366.8	27.5	339.3
<b>MONITORING WELLS</b>	XJM-93-01X	369.2	13.2	356
	XJM-93-02X	371.1	17.5	353.6
	XJM-93-03X	368.5	NE	NA
	XJM-93-04X	368.7	0.7	368
	XJM-94-05X	368.9	16.1	352.8
	XJM-94-06X	367.9	16	351.9
	XJM-94-07X	362.2	NE	NA
	XJM-94-08X	366.7	NE	NA
	XJM-94-09X	369	22	347
	XJM-94-10X	369	22.5	346.5
	2446-01	369.8	NE	NA
	2446-02	369	NE	NA
	2446-03	369.5	NE	NA
	2446-04	369.6	NE	NA
<b>PIEZOMETERS</b>	XJP-94-01X	368.8	16.5	352.3
	XJP-94-02X	368.5	17.2	351.3
	XJP-94-03X <sup>2</sup>	362.5	58.5	304

**Notes:**

<sup>1</sup> Top of bedrock defined by split-spoon and/or auger refusal.

<sup>2</sup> A piezometer was not installed in XJP-94-03X.

bgs = below ground surface

MSL = Mean Sea Level

NA = Not Applicable

NE = Not Encountered



TABLE 6-2  
SUMMARY OF WATER LEVEL ELEVATION DATA  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
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WELL/ PIEZOMETER ID1	REF. POINT	ELEV. OF REF. POINT (FEET/MSL)	OCTOBER 4, 1994		JANUARY 31, 1995		MAY 9, 1995	
			DEPTH TO WATER (FEET)	ELEV. OF WATER (FEET/MSL)	DEPTH TO WATER (FEET)	ELEV. OF WATER (FEET/MSL)	DEPTH TO WATER (FEET)	ELEV. OF WATER (FEET/MSL)
XJM-93-01X	PVC	371.40	7.85	363.35	6.10	365.10	6.65	364.55
XJM-93-02X	PVC	370.63	12.08	358.36	10.13	360.31	3.82	366.62
XJM-93-03X	PVC	368.02	8.59	359.29	6.32	361.56	4.61	363.27
XJM-93-04X	PVC	371.17	8.2	362.77	6.44	364.53	6.35	364.62
XJM-94-05X	PVC	368.51	Not Installed	Not Installed	5.8	362.71	5.27	363.24
XJM-94-06X	PVC	367.36	Not Installed	Not Installed	6.9	360.46	5.10	362.26
XJM-94-07X	PVC	365.04	Not Installed	Not Installed	6.8	358.24	7.60	357.44
XJM-94-08X	PVC	369.27	Not Installed	Not Installed	9.39	359.87	10.60	358.67
XJM-94-09X	PVC	371.58	Not Installed	Not Installed	7.94	363.68	9.36	362.22
XJM-94-10X	PVC	371.39	Not Installed	Not Installed	8.43	362.99	9.56	361.83
2446-02	PVC	368.91	8.30	359.51	Not Measured	Not Measured	Not Measured	Not Measured
2446-03	PVC	369.16	9.38	358.43	Not Measured	Not Measured	Not Measured	Not Measured
2446-04	PVC	369.38	10.25	357.56	Not Measured	Not Measured	Not Measured	Not Measured
XJP-94-01X	PVC	368.51	Not Installed	Not Installed	5.94	362.61	5.27	363.24
XJP-94-02X	PVC	368.27	Not Installed	Not Installed	6.21	362.07	5.62	362.65

Notes:

1 Monitoring well 2446-01 has been destroyed.

MSL = Mean Sea Level

PVC = Polyvinyl chloride





**TABLE 6-3**  
**SUMMARY OF IN-SITU HYDRAULIC CONDUCTIVITY TEST RESULTS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

			HYDRAULIC CONDUCTIVITY	
WELL ID	MEDIA SCREENED	TYPE OF TEST	HVORSLEV (1951) (cm/sec)	BOUWER AND RICE (1976) (cm/sec)
REMEDIAL INVESTIGATION				
XJM-94-05X	SOIL	RISING HEAD	8.50E-06	9.60E-07
XJM-94-07X	SOIL/BOULDER	RISING HEAD	5.60E-04	8.40E-04
XJM-94-08X	SOIL	RISING HEAD	1.70E-03	1.60E-03
XJM-94-09X	SOIL	FALLING HEAD	3.90E-05	1.90E-04
XJM-94-09X	SOIL	RISING HEAD	7.20E-05	2.10E-04
XJM-94-10X	SOIL	FALLING HEAD	1.00E-06	4.40E-04
2446-02	SOIL	RISING HEAD	9.50E-06	3.40E-05
2446-03	SOIL	RISING HEAD	2.10E-05	9.60E-05
2446-04	SOIL	FALLING HEAD	7.60E-06	3.30E-05
2446-04	SOIL	RISING HEAD	6.80E-06	2.80E-05
XJP-94-01X	SOIL	RISING HEAD	3.70E-04	4.00E-04
XJP-94-02X	SOIL	FALLING HEAD	1.60E-05	6.60E-05
XJP-94-02X	SOIL	RISING HEAD	3.30E-04	2.90E-03

**Notes:**

cm/sec = centimeters/second





## **7.0 NATURE AND DISTRIBUTION OF DETECTED SITE CONTAMINANTS**

The following subsections address the nature and distribution of analytes detected in soil and groundwater collected from AOC 43J during the 1992 SI, the 1993 SSI, and the 1994 RI. Fort Devens background soil and groundwater data are also presented to aid in the assessment of site-related data. Analytes detected in QC blanks are presented to assess potential contamination of analytical samples introduced during sample preparation and analysis. A complete discussion of the laboratory QC sample results is presented in Subsection 3.2 and Appendix D of this report.

In addition to data obtained from off-site analytical laboratory analysis, field analytical data are presented and discussed. During implementation of field programs, field screening results were used to direct placement of soil borings, test pits, and monitoring wells used to define the vertical and/or horizontal distribution of contaminants. Screening results were also used to select off-site laboratory samples. Samples were collected from hot zones to gather information on the nature and concentrations of contaminants, and samples were collected from clean areas for off-site confirmation. Field analytical data are used in the following subsections to complement off-site laboratory analytical data in the assessment of the nature and distribution of detected analytes. A review of field laboratory quality control sample analyses from the RI program is presented in Appendix D.

This assessment of site-related contaminants relies heavily upon figures and tables to present the field and off-site laboratory analytical data. Figures and hits-only data tables (containing detected analytes and concentrations for samples within a given media), which were used to create the figures, are presented at the end of this section. The text within the assessment provides detail, interpretation, and analysis that cannot be presented in the figures.

### **7.1 APPROACH TO CONTAMINATION ASSESSMENT**

Off-site laboratory analytical results and field analytical data are the primary data used to assess impacts at the site from suspected past disposal practices. Where

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applicable, pre-1994 analytical data have been used to assess contaminant impacts at AOC 43J. The pre-1994 data presented in the contamination assessment were obtained by ABB-ES during the SI and SSI phases of investigation. A summary of pre-1994 and 1994 analyses performed on samples from all media is presented in Table 5-4.

Detected analytes and concentrations in field analytical and off-site laboratory analytical data have been displayed on figures to aid the reader. Field analytical and off-site laboratory hits-only data shown on the figures are also presented in tables at the end of the section. A complete data set of field and off-site analytical data is presented in Appendix M. Off-site laboratory analytical results for samples that showed no detections for an entire analytical method (e.g., VOCs) are not listed in the hits-only tables. In addition, tentatively identified compounds (TICs) are discussed in Subsection 7.1.1 and presented in Table 7-1. Fort Devens calculated inorganic background concentrations for analytes detected in soil and groundwater are presented in each off-site laboratory hits-only data table. A discussion of the Fort Devens background concentrations is presented in Subsection 4.3 and Appendix L of the report.

A blank contamination evaluation was performed as described in Subsection 7.1.2. This evaluation resulted in the identification of probable laboratory-related contaminants. All data presented in figures and tables are uncorrected for blank contamination, although a "\*" has been added to indicate probable blank contaminants. Discussions in the contamination assessment evaluate uncertainty regarding potential false positives due to sampling and laboratory contaminants.

### 7.1.1 Tentatively Identified Compounds/Non-Project Analyte List Compounds

Volatile and semivolatile TICs and unknown compounds were detected in several soil boring samples and groundwater collected from AOC 43J. These compounds are differentiated from target analytes in the USAEC's IRDMIS with an "S" flag in the flagging code field. All TICs associated with soil boring samples from AOC 43J are summarized and presented in Table 7-1.

Compounds were tentatively identified by comparing the GC/mass spectroscopy (MS) spectra to those contained in the National Bureau of Standards mass

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spectral library. Once the tentative identification was made based on matching spectra, the appropriate USAEC code name was assigned for that compound.

Reported concentrations are considered estimated and are not based on calibration standards. If no compound identification was possible, the compound became listed as an unknown with an assigned number. The assigned number which accompanies the prefix "UNK" is determined by the relative retention time to the internal standard. For example, if the relative retention time of the compound compared to 1,4-difluorobenzene is 1.42, the compound would be assigned the number "UNK142" in IRDMIS.

The requirements for making tentative identification of compounds are listed in the Fort Devens POP as follows:

1. Relative intensities of major ions in the reference spectrum (ions > 10 percent of the most abundant ion) should be present in the sample spectrum.
2. The relative intensities of the major ions must agree within 20 percent.
3. Molecular ions present in the reference spectrum should be present in the sample spectrum.
4. Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of co-eluting compounds.
5. Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or co-eluting compounds. Data system library reduction programs can sometimes create these discrepancies.
6. If in the technical judgment of the mass spectral interpretation specialist, no valid tentative identification can be made, the compound should be reported as unknown.

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VOC and SVOC TICs were detected in soil boring samples collected at AOC 43J. Semivolatile TICs included heavyweight alkanes such as pentadecane, hendecane, octadecane, nonadecane, cosane, tricosane, and pentacosane (see Table 7-1). Estimated concentrations of individual compounds ranged from 0.0065  $\mu\text{g/g}$  to 1.1  $\mu\text{g/g}$ . Detection of these compounds is attributable to fuel contamination. Samples for which contamination of heavyweight alkanes was observed include BXXJ0205, BXXJ0207, and BXXJ0311. Lighter weight alkanes such as heptane, octane, and nonane were also detected using GC/MS SVOC analytical methods. Estimated concentrations of the lighter alkanes ranged from .0044  $\mu\text{g/g}$  to 70  $\mu\text{g/g}$ . Compounds such as heptane and octane are likely associated with gasoline contamination. Samples with contamination of light weight alkanes include BXXJ0311, BXXJ0315, BXXJ0612, BXXJ0807, BXXJ0809, BXXJ1107, BXXJ1111, BXXJ1211, and BXXJ1620.

In addition to alkanes, alkyl-substituted benzenes were detected in soil boring samples associated with AOC 43J. Examples of these types of compounds include 1,2,3-trimethylbenzene; 1,2-dimethylbenzene; 1,4-dimethylbenzene; 1,3,5-trimethylbenzene; 1-ethyl-2-methylbenzene; 1-methyl-4-(1-methylethyl)benzene; and 1,2,3,5-tetramethylbenzene. These compounds were detected in concentrations ranging from 0.11  $\mu\text{g/g}$  to 1.2  $\mu\text{g/g}$ . Samples associated with detections of substituted benzene include BXXJ0311, BXXJ0207, BXXJ0612, BXXJ0809, BXXJ1107, and BXXJ1111. The detection of these compounds is generally associated with gasoline contamination.

Other compounds detected in soil boring samples collected from AOC 43J include methylcyclohexane; 2-methylheptane; 2-methylhexane; 3-methylhexane; 2-methylpentane; 3,7-dimethylnonane; 1-methylnaphthalene; and 3-propyltoluene. Concentrations of these compounds ranged from .0042  $\mu\text{g/g}$  for methylcyclohexane to 50  $\mu\text{g/g}$  for 2-methylhexane. Samples associated with detections of these TICs include BXXJ0311, BXXJ0807, BXXJ0809, BXXJ1107, BXXJ1111, and BXXJ1211. The presence of these compounds is probably representative of gasoline contamination.

AOC 43J samples had concentrations of unknown compounds ranging from 0.005  $\mu\text{g/g}$  to 50  $\mu\text{g/g}$ . Specific samples with detections of unknowns include BXXJ0207, BXXJ0311, BXXJ0807, BXXJ0809, BXXJ1007, BXXJ1107, BXXJ1111, BXXJ1211, and BXXJ1620.

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It is important to note that in addition to the GC/MS method used to identify and report the alkanes and aromatics identified as TICs, USEPA Method 418.1 was used during the off-site analysis of soil and water samples to quantify hydrocarbons within these chemical classes. Field screening was conducted on many samples during the 1992, 1993, and 1994 field programs using a modified version of USEPA Method 418.1. The on-site screening method was designed to provide data on the distribution of these fuel hydrocarbons. On-site results were used to direct field exploration programs and provide supporting data for the off-site sample results. The off-site laboratory USEPA Method 418.1 results are the primary data used to make quantitative evaluations of these chemicals as TPHC.

### 7.1.2 Potential Laboratory and Sampling Contaminants

An evaluation of results from rinsate, trip, and laboratory method blank analyses was conducted to determine possible target analyte contaminant contributions originating from non-site-related sources. Blank data associated with AOCs 43G, 43J, and 41 for the Fort Devens SI, SSI, and RI were used for this evaluation. Potential sources of contamination include materials used during borehole advancement and monitoring well installation, field sampling procedures, field equipment decontamination, sample shipment, laboratory storage, and laboratory processing. Detailed discussions of blank contamination for the RI, SI and SSI are contained in Section D.2.0 of Appendix D.

Because the majority of off-site analytical data was generated using USAEC methods, USEPA data validation guidelines related to the evaluation of blank contamination were not implemented. In addition, action levels were not established. The following approach is taken in the report regarding laboratory method blank and field QC sample blank contamination:

#### Organic analytes:

- 1) For non-target VOCs and SVOCs reported as TICs common organic laboratory contaminants identified by the USEPA Draft National Functional Guidelines for Organic Data Review (USEPA, 1991) are not considered contaminants of concern. The common organic laboratory contaminants identified in this document include:

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- Siloxanes; diethyl ether; 1,1,2-trichloro-1,2,2-trifluoroethane; fluorotrichloromethane; and phthalates at levels less than 100  $\mu\text{g/L}$  or 4  $\mu\text{g/g}$ .
  - Solvent preservatives such as cyclohexane, and related by-products including cyclohexanone, cyclohexenone, cyclohexanol, cyclohexenol, chlorocyclohexene, and chlorohexanol.
  - Aldol condensation products of acetone including 4-hydroxy-4-methyl-2-pentanone; 4-methyl-2-penten-2-one; and 5,5-dimethyl-2(5H)-furanone.
  - Additional TICs were detected in blanks. The additional TICs detected in SVOA blanks include 1,2-epoxycyclohexene, mesityl oxide, 2-ethyl-1-hexanol, and hexanedioc acid dioctylester. These compounds have been identified as contaminants in contaminant assessments presented in this document.
- 2) For organic target compounds trends in method and field blanks were evaluated for each sampling program. Several target compounds have been identified by USEPA as common laboratory contaminants including:
- phthalates
  - Methylene chloride, acetone, toluene, and methyl ethyl ketone (2-butanone) at concentrations comparable to concentrations observed in blanks.

Organic analytes detected in QC blanks are presented in Table 7-2 through 7-4. Organic compounds detected in samples at similar concentration ranges as those in blanks are discussed qualitatively in the contamination assessment, but may not be carried through the risk assessment calculations. In addition, the spatial distribution and relative concentration of common organic laboratory contaminants, and rationale for elimination of data from consideration as site-related contaminants, are presented in the contamination assessment in Section 7.0.

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Inorganic Analytes: Inorganics present in rinsate blanks and method blanks in Sections 7.0 and 8.0 are presented in Table 7-2 through 7-4. Sample data as reported in the figures, data tables, and risk assessment tables are uncorrected. The risk assessments carry all inorganic detections through the calculations. QC blank data is qualitatively evaluated for inorganics exceeding risk thresholds.

During the SSI and RI programs samples were analyzed for a variety of water quality indicators to generate data to support the development of alternatives during the FS process. Low concentrations of method blank contamination was reported for TSS ( $\leq 8,000 \mu\text{g/L}$ ), hardness ( $\leq 16,000 \mu\text{g/L}$ ), and TDS ( $\leq 12,000 \mu\text{g/L}$ ). It is possible that similar concentrations reported in samples may be related to laboratory contamination. Laboratory contamination in these methods at the above concentrations does not impact the contamination and risk assessments presented in the document.

Tables 7-2 through 7-4 present a summary of analytes detected in method blanks, rinsate blanks, and trip blanks. The data contained in these tables are representative of detected analytes in AOCs 43G, 43J, and 41 for the Fort Devens SI, SSI, and RI. Inorganic detections in the soil method blanks are not included in Table 7-2 because the elements detected do not represent laboratory contamination as discussed in Appendix L, Section L.2.0. The elements have been detected at consistent concentrations in these blanks throughout several investigations.

### 7.1.3 Analytical Data Accuracy and Precision

Analytical data accuracy and precision was evaluated using results of matrix spikes (MS) and field duplicate analyses for the majority of off-site analytical methods conducted to support the Devens field programs. Surrogate recoveries were reviewed to evaluate the accuracy of VOA and SVOA measurements. Detailed discussions and presentation of these results are included in Appendix D.

Matrix spike, field duplicate, and surrogate results for the majority of the methods and target analytes evaluated during the SI, SSI, and RI indicate the accuracy and precision of results were within project goal outlined in the Fort Devens POP (ABB-ES, 1992) and USEPA control limits (USEPA, 1988; USEPA, 1989). Trends were reviewed for each set of QC sample data from each field event to

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determine if qualification of the accuracy of results was needed. Some analytes in groundwater and soil analyses have been identified as estimated with potential biases included. The following items summarize the qualification of results:

1. Based on MS recoveries from the SI and RI analyses, concentrations of antimony and selenium in groundwater are potentially biased low. Selenium was not detected in any groundwater samples collected during the SI, SSI, or RI, and selenium is not interpreted to be important at any of the study areas.
2. Based on MS recoveries for unfiltered groundwater samples during the SI, concentrations reported for arsenic, chromium, copper, lead, nickel, thallium, and zinc are potentially biased low. Similar trends were not observed for the filtered sample analyses associated with the SI field program. These sample locations were recollected during subsequent field programs and similar matrix effects trends were not apparent.
3. Based on MS recoveries for soils from the SI analyses, magnesium and selenium results are potentially biased low. Selenium low recoveries were also reported in the RI MS analyses. No selenium was reported in any soil samples and selenium is not interpreted to be important at the Devens sites.
4. Based on MS recoveries for soils from the SSI analyses, arsenic results are potentially biased high. Arsenic concentrations in all samples were below risk levels so the effect of high biased results do not affect risk interpretations.
5. Based on MS recoveries for soils from the RI analyses, results for aluminum, arsenic, iron, magnesium, and manganese are considered estimated values. MS recoveries were reported both above and below project recovery goals and no specific bias is identified.
6. Based on differences observed in field duplicate sample results for target PAHs in sediments and soil samples analyzed during the SSI

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and RI, PAH in soils and sediments are considered estimated values.

7. Based on differences observed in field duplicate results for TOC and TPHC in soil and sediments collected during the RI, TOC and TPHC results are considered to be estimated.
8. Based on differences observed in field duplicate soil results for the VOC 1,1,2,2-tetrachloroethane during the RI, results for this compound in soil are considered estimated.
9. Based on differences observed in field duplicate groundwater results for TKN during the RI, TKN results are considered estimated. TKN was collected for use in designing remedial options for groundwater and this parameter is not used in the contamination or risk assessments.
10. VOA Surrogate Recovery Evaluations:
  - Concentrations of xylenes (0.022  $\mu\text{g/g}$ ) in sample BX43J105 collected during the SI may be biased high.
  - Non-detect CRLs and detected target compound concentrations are considered estimated for sample MXXJ01X2 collected during the SSI.
  - Based on high surrogate recoveries for one or two surrogates, concentrations of BTEX compounds reported in RI samples BXXJ0809 and BXXJ0612 are considered estimated and possibly biased high.
  - Based on high recoveries of surrogate 1,2-dichloroethane-D4 in RI samples MXXJ02X3, MXXJ03X3, MXXJ03X4, MXXJ05X3, MXXJ06X4, MXXJ08X3, MXXJ09X3, MXXJ09X4, and MDXJ07X4, concentrations of target compounds in these samples are considered estimated and possibly biased high.

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- Based on low recoveries of 4-bromofluorobenzene and/or toluene-D8 reported in samples MXXJ01X4, MXXJ06X3, MXXJ08X4, and MXXJ09X4, concentrations reported for detected target compounds and CRLs for non-detected target compounds are considered estimated and possibly biased low, however, a large bias is not suspected based on acceptable recoveries observed for the other surrogates.

### 11. SVOA Surrogate Recovery Evaluation:

- Acid fraction compound CRLs for groundwater samples MXXJ02X1, MXXJ02X2, and MXXJ03X2 are considered estimated and potentially biased low.
- Two high base-neutral surrogate recoveries were reported in BXXJ1107. Base-neutral target compounds naphthalene and 2-methylnaphthlene were detected in sample BXXJ1107. These results are considered estimated and possibly biased high.

## 7.2 CONTAMINATION ASSESSMENT

The following subsections assess compounds and analytes detected in subsurface soil and groundwater samples collected during each of the field investigations at AOC 43J.

### 7.2.1 Soil

The following subsections present field and off-site laboratory analytical soil results for samples collected at AOC 43J. Field analytical soil data are presented in Tables 7-5 through 7-8, and in graphical form in Figures 7-1 through 7-4. Off-site laboratory analytical soil data are presented in a hits-only table, Table 7-9. Complete field analytical and off-site laboratory analytical soil data results are presented in Appendix M. A summary of analyses performed on all soil samples is presented in Table 5-2.

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**7.2.1.1 Field Analytical Soil Results.** Soil samples were collected for field analysis from the TerraProbe<sup>SM</sup> points and/or soil borings during each phase of investigation. The field analytical samples were collected in an attempt to define the nature and distribution of the site-related contaminants in and around the former UST locations and downgradient of the former USTs. A discussion of the results for each exploration type is presented below.

**UST Removal Results.** Prior to the beginning of the 1992 SI field program ATEC had removed a 1,000-gallon waste oil UST approximately 50 feet to the east of AOC 43J (see Figure 7-1). Not all of the contaminated soil was removed from this excavation due to the large distribution of contamination. ATEC performed field screening on 10 soil samples collected from the sides and bottom of the UST excavation (SS-1 through SS-10). Total VOC concentrations (measured by a PID in soil headspace) ranged from ND to 16.8 ppm, and TPHC concentrations measured on an NDIR unit, ranged from 11.5 to 864.9  $\mu\text{g/g}$ . Off-site laboratory analytical samples from the excavation showed TPHC concentrations ranging from 74  $\mu\text{g/g}$  to 918  $\mu\text{g/g}$  (ATEC, 1992a) (see Table 7-5). Because the contamination from this UST had migrated beyond the excavation, it was determined by Fort Devens EMO personnel that the excavation should be backfilled and additional investigations be conducted to determine the distribution of contamination.

As part of the SI conducted by ABB-ES in 1992, a metal detector and GPR survey were conducted at the historic gas station to determine if the gas station's UST and/or associated piping were still present. The results of the surveys indicated that one abandoned UST was present at the site. This UST was added to the installation's UST removal program, and on August 26, 1992 ATEC removed one 5,000-gallon UST (see Figure 7-1). At the time of the removal, the UST's contents consisted of gasoline and sludge. Visually contaminated soil and strong fuel odor were observed in the soil around the excavation (ATEC, 1992b). ATEC performed field screening on eight soil samples collected from the sides and bottom of the UST excavation (SS-1 through SS-8). VOC concentrations (measured by a PID in soil headspace) ranged from 100.0 to 400.0 ppm, and TPHC concentrations measured on an NDIR unit, were from 43.9 to 3,534.8  $\mu\text{g/g}$  (ATEC, 1992b) (see Table 7-5). Off-site laboratory analytical samples showed total VOCs ranging from 0.572  $\mu\text{g/g}$  to 2.2  $\mu\text{g/g}$ , and TPHC concentrations ranging from non-detect to 2,170  $\mu\text{g/g}$ . A laboratory analytical water sample

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(LWS-1) was collected from the water in the excavation, and the results showed a total VOC concentration of 0.132  $\mu\text{g/g}$  and a TPHC concentration of 114  $\mu\text{g/g}$  (see Table 7-5).

Based on the results of the ATEC field screening, additional soil was removed from the excavation. Bedrock was reached at approximately 8 feet bgs. Groundwater was encountered in the northern corner of the excavation. The lateral distribution of the contamination was not determined during this cleanup process due to physical restriction (e.g., driveways, buildings, stockpiled soil). Because of this, the installation decided to stop the cleanup process, line the excavation with polyethylene sheeting, and backfill the excavation.

TerraProbe<sup>SM</sup> Field Analytical Sample Results. Soil samples were collected for field analysis from TerraProbe<sup>SM</sup> points completed during the SI, SSI, and the RI field programs. SI and SSI TerraProbe<sup>SM</sup> soil samples were analyzed for BTEX and TPHC. RI TerraProbe<sup>SM</sup> soil samples were analyzed for BTEX, TPHC, and select chlorinated solvents to identify potential waste oil contaminants (see Table 5-2). Figures 7-1 through 7-4 present total BTEX and TPHC concentration contour maps of TerraProbe<sup>SM</sup> soil field analytical data for soil samples collected during the SI, SSI, and RI field programs. The following paragraphs discuss chronologically, the TerraProbe<sup>SM</sup> soil sample field analytical results from these investigations.

TerraProbe<sup>SM</sup> points were completed by ABB-ES during the SI to investigate the distribution of contamination associated with the former 5,000-gallon UST removed from the historic gas station. A total of nine soil samples, from TerraProbe<sup>SM</sup> points TS-01, TS-03, and TS-05 through TS-10, were collected and analyzed for BTEX and TPHC (see Figure 7-1). The TerraProbe<sup>SM</sup> points could not be advanced deeper than 4 to 9 feet bgs because of subsurface obstruction and/or bedrock. BTEX was detected in four of the nine samples collected, with individual concentrations ranging from 0.260  $\mu\text{g/g}$  for o-xylene (TS-01, 9 feet) to 17  $\mu\text{g/g}$  for toluene (TS-03, 9 feet). TPHC was detected in six of the nine samples at concentrations ranging from <55 to 940  $\mu\text{g/g}$  (TS-03, 9 feet)(see Table 7-6).

An additional 15 TerraProbe<sup>SM</sup> points (TS-11 through TS-14, TS-16 through TS-20, and TS-22 through TS-27) were completed during the SSI field

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investigation to further define the distribution of the residual soil contamination in and around the former 1,000-gallon waste oil UST. Soil samples were collected from 9 to 10 feet bgs (the apparent top of the bedrock), and analyzed for BTEX and TPHC. The TerraProbe<sup>SM</sup> points were concentrated in and around the former waste oil UST excavation in front of Building T2446 (see Figure 7-1). The results of the field analyses indicate the presence of TEX at the northeast, southeast and southwest sides of the excavation. TEX was detected in 12 of the 16 samples collected, with individual minimum and maximum concentrations ranging from 0.0008  $\mu\text{g/g}$  for o-xylene (TS-17, 8 feet) to 6.4  $\mu\text{g/g}$  for m/p-xylene (TS-25, 8 feet). TPHC was detected in five of the 16 samples, at concentrations ranging from 110  $\mu\text{g/g}$  (TS-22, 8 feet) to 3,100  $\mu\text{g/g}$  (TS-25, 8 feet) (see Table 7-6). The distribution of the contamination was roughly defined on the northwest and west sides of the excavation, however the northeast, east and southern sides were not fully defined during the SSI.

The 1994 RI field investigation included the completion of an additional 48 TerraProbe<sup>SM</sup> points to assess the vertical and horizontal distribution of residual soil contamination. The TerraProbe<sup>SM</sup> points were located hydraulically downgradient (east) from the former USTs and from points completed during the SI and the SSI (see Figure 7-1). Soil samples were collected from 7 to 9 feet and 9 to 11 feet bgs (at and below the water table) and analyzed for BTEX, TPHC, and select chlorinated solvents (see Table 7-7).

Figure 7-1 shows the distribution of BTEX in the soil samples from zero to 9 feet bgs, while Figure 7-2 shows the distribution of TPHC in soil samples collected from the same depth. The majority of samples for which the data are presented on these figures were collected from the 7 to 9 feet bgs interval. Figure 7-3 shows the distribution of BTEX in the soil samples from 9 to 11 feet bgs, while Figure 7-4 shows the distribution of TPHC in soil samples collected from the same depth. These figures use the field analytical data collected from all three (SI, SSI, and RI) field investigations.

The results of the field analyses indicate the presence of BTEX in soil primarily to the south of the waste oil UST excavation, at distances up to 180 feet (see Tables 7-6, 7-7, and Figure 7-1). BTEX was detected in 40 of the 90 samples analyzed, with individual minimum and maximum concentrations ranging from 0.0028  $\mu\text{g/g}$  for toluene (TS-75, 7 feet) to 56  $\mu\text{g/g}$  for m/p-xylene (TS-67, 7 feet).

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The highest concentrations of total BTEX were found at TerraProbe<sup>™</sup> points TS-31, TS-35, TS-43, TS-45, TS-53, TS-54, TS-56, TS-64, TS-66, TS-67, and TS-68. These points are located due south of the former waste oil UST. TPHC was detected in 40 of the 90 samples at concentrations ranging from 74  $\mu\text{g/g}$  (TS-54, 9 feet) to 6,600  $\mu\text{g/g}$  (TS-35, 7 feet) (see Table 7-5). Detection of TPHC was generally coincident with detection of BTEX. Figures 7-1 through 7-4 show that the TerraProbe<sup>™</sup> points defined the horizontal distribution of fuel-related contamination. T-1,2-DCE was detected in one sample (TS-83, 9 feet) at a concentration of 0.0024  $\mu\text{g/g}$ , which is just above the detection limit of 0.0022  $\mu\text{g/g}$ . No other chlorinated solvents were detected in the TerraProbe<sup>™</sup> soil samples collected during the RI.

**Soil Boring Sample Results.** Soil samples were collected for field analysis from each of the 15 soil borings (XJB-94-02X through XJB-94-16X) completed during the 1994 RI field investigation (see Figure 7-5). Soil samples were collected at 5-foot intervals from each of the borings (except XJB-94-04X which was sampled continuously) and analyzed in the field for BTEX, TPHC, and selected chlorinated solvents (Table 7-8). The samples were analyzed in the field laboratory to assist in selection of off-site laboratory analytical samples. Figures 7-5 and 7-6 show the distribution of BTEX and TPHC, respectively, in the soil samples from zero to 15 feet bgs. Off-site laboratory results for soil samples collected below 15 feet bgs are presented in Table 7-8. Note that some soil borings have no samples or more than one sample per interval (zero to 15 feet bgs or 15 feet bgs to top of bedrock). If a boring has two or more samples with detects in the same interval, the sum of the detects (of BTEX and/or TPHC) over that interval is reflected in the figure.

The results of the field analyses indicate the presence of BTEX primarily to the south of the waste oil UST excavation, with horizontal and vertical distribution closely corresponding to RI TerraProbe<sup>™</sup> soil sample results (see Table 7-7 and 7-8, Figure 7-1 to 7-3). BTEX was detected in 23 of the 60 samples analyzed, with individual minimum and maximum concentrations ranging from 0.0031  $\mu\text{g/g}$  for toluene (XJB-94-12X, 9 feet) to 180  $\mu\text{g/g}$  for m/p-xylene (XJB-94-11X, 7 feet). The highest concentrations of total BTEX were found at soil borings XJB-94-03X, XJB-94-08X, and XJB-94-11X. These points are located to the south of the former waste oil UST (see Figure 7-4). TPHC was detected in 26 of the 60 samples at concentrations ranging from 100  $\mu\text{g/g}$  to 3,400  $\mu\text{g/g}$  (see

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Table 7-7 and 7-8; Figure 7-4). Detection of TPHC was generally coincident with detection of BTEX. No chlorinated solvents were detected in any of the field analytical soil samples collected during the RI. Figures 7-1 through 7-4 reveal agreement with the TerraProbe<sup>SM</sup> results, indicating the fuel-related contamination extends southward from the waste oil UST, but does not extend beyond the southern corner of the fenced area of AOC 43J.

**7.2.1.2 Off-Site Laboratory Analytical Soil Results.** One soil boring (43J-92-01X) was drilled during the SI to confirm the field analytical results. This boring was located approximately 5 feet east of the former historic gas station UST and was advanced to 6.2 feet bgs. One subsurface soil sample was collected from 5 feet bgs for off-site laboratory analysis. Xylene was detected in the sample at 0.022  $\mu\text{g/g}$ , TPHC at 1,770  $\mu\text{g/g}$ , and lead was detected below the Fort Devens background concentration (see Table 7-9). Groundwater was not encountered in this boring.

One subsurface soil sample was collected from three of the four SSI monitoring well borings (XJM-93-01X through XJM-93-03X) completed at AOC 43J and submitted for off-site laboratory analysis. A subsurface soil sample was not collected from XJM-93-04X due to the very shallow depth to bedrock (0.7 feet bgs). Probable laboratory contaminants acetone, di-n-butyl phthalate, and trichlorofluoromethane (freon) were the only organic analytes detected in the subsurface soil samples collected. These compounds were detected at concentrations of less than 0.15  $\mu\text{g/g}$ . Acetone, di-n-butyl-phthalate, and freon were also detected in soil method blanks (run during the analysis of SSI soil samples) and trip blanks indicating that these compounds are attributable to laboratory contamination (see Table 7-1). The results of the off-site laboratory analyses did indicate the presence of several inorganic analytes above their Fort Devens background concentrations. The analytes included arsenic, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, and zinc. The majority of these analytes were detected in the 5-foot and 10-foot samples from XJM-93-02X. TPHC was also detected at a concentration of 220  $\mu\text{g/g}$  in the 5-foot sample from XJM-93-02X. TPHC was not detected in the other samples collected (see Table 7-9).

A total of 15 soil borings (XJB-94-02X through XJB-94-16X) were completed to bedrock during the RI to further define the horizontal and vertical distribution of



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soil contamination downgradient of the former UST locations (see Figure 5-5). Soil samples were collected at 5-foot intervals in each of the borings. Two samples from each boring were submitted for off-site laboratory analysis (see Table 5-2).

Site-related VOCs detected in RI soil boring samples include ethylbenzene, toluene, and xylenes (see Table 7-9). Probable laboratory contaminants acetone, chloroform, and trichlorofluoromethane (freon) were also detected in some samples at relatively low concentrations (see Table 7-1). These analytes are not considered to be site-related contaminants (see Subsection 7.1.2). Ethylbenzene was detected in 7 of 31 samples, at concentrations ranging from 0.0042  $\mu\text{g/g}$  (XJB-94-10X, 7 feet) to 30  $\mu\text{g/g}$  (XJB-94-11X, 7 feet). Toluene was detected in 5 of 31 samples, at concentrations ranging from 0.1  $\mu\text{g/g}$  (XJB-94-08X, 7 feet) to 20  $\mu\text{g/g}$  (XJB-94-08X, 9 feet). Xylenes were detected in 7 of 31 samples, at concentrations ranging from 0.0063  $\mu\text{g/g}$  (XJB-94-10X, 7 feet) to 100  $\mu\text{g/g}$  (XJB-94-08X, 9 feet). Distribution and concentrations of TEX are horizontally and vertically consistent with TerraProbe<sup>™</sup> and soil boring field analytical data. The highest concentrations of TEX were detected in soil borings XJB-94-03X (11 feet), XJB-94-08X (7 and 9 feet) and XJB-94-11X (7 and 11 feet) which are located within 50 feet of the former UST excavations. Lower concentrations detected in soil borings XJB-94-06X and XJB-94-10X located further southeast of the former UST location (see Table 7-9). Detection of VOC TICs and unknown compounds in soil boring samples is spatially consistent with detection of VOCs mentioned above and are indicative of fuel contamination (see Subsection 7.1.1 and Table 7-1).

Site-related SVOCs detected in RI soil boring samples include 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene (see Table 7-9). BEHP and di-n-butyl phthalate were also detected in RI soil samples, however, these compounds appear to be laboratory contaminated based on the off-site laboratory QC program. These phthalates are not considered to be site-related contaminants (see Subsection 7.1.2). 2-methylnaphthalene was detected in six of 31 samples, at concentrations ranging from 0.093  $\mu\text{g/g}$  (XJB-94-06X, 12 feet) to 7  $\mu\text{g/g}$  (XJB-94-11X, 7 feet). Naphthalene was detected in five of 31 samples, at concentrations ranging from 0.71  $\mu\text{g/g}$  (XJB-94-08X, 9 feet) to 10  $\mu\text{g/g}$  (XJB-94-11X, 7 feet). Phenanthrene and pyrene were detected in one soil sample (XJB-94-12X, 7 feet), at concentrations of 0.5  $\mu\text{g/g}$  and 0.7  $\mu\text{g/g}$ , respectively.

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Distribution of these SVOCs is generally horizontally and vertically consistent with that of the detected VOCs, with the exception of phenanthrene and pyrene. Phenanthrene and pyrene are the only SVOCs detected in the 7-foot sample from XJB-94-12X. In addition, no VOCs were detected in this sample (see Table 7-9). Detection of SVOC TICs and unknown compounds in soil boring samples is spatially consistent with detection of SVOCs mentioned above (see Subsection 7.1.1 and Table 7-1).

TPHC was detected in 22 of 31 RI soil boring samples at concentrations ranging from 34.5  $\mu\text{g/g}$  (XJB-94-09X, 9 feet) to 1,880  $\mu\text{g/g}$  (XJB-94-11X, 7 feet). TPHC concentrations exceeded 500  $\mu\text{g/g}$  in soil samples collected from XJB-94-07X (11 feet, duplicate sample), XJB-94-11X (7 feet), and XJB-94-12X (7 feet) (see Table 7-9).

The results of laboratory analyses did indicate the presence of several inorganic analytes above their Fort Devens background concentrations (see Table 7-9). The analytes exceeding Fort Devens background concentrations include antimony, arsenic, barium, calcium, chromium, cobalt, copper, iron, lead, manganese, nickel, potassium, sodium, and zinc. The spatial distribution of inorganic analytes exceeding background concentrations is not consistent with the detection of fuel-related VOCs and SVOCs. Calcium, cobalt, copper, manganese, nickel, and sodium exceeded Fort Devens background concentrations in the majority of subsurface soil samples collected (see Table 7-9). The remaining inorganic analytes were detected above Fort Devens background concentrations in fewer samples. Lead was detected above its background concentration of 48  $\mu\text{g/g}$  in two samples: XJB-94-12X at 7 feet (86  $\mu\text{g/g}$ ) and XJB-94-13X at 9 feet (54  $\mu\text{g/g}$ ). Detection of lead above Fort Devens background concentrations at these locations does not appear to correlate with detection of fuel-related VOCs (see Table 7-9). The inorganic concentrations appear to be representative of site-related background.

**7.2.1.3 Summary of Soil Impacts.** Field analytical and off-site analytical laboratory data from TerraProbe<sup>SM</sup> and soil boring samples indicate that the former gasoline and waste oil USTs were the sources for the existing subsurface soil contamination at AOC 43J. Primary contaminants detected in the subsurface soil samples were BTEX, 2-methylnaphthalene, naphthalene, phenanthrene, pyrene, and TPHC. These VOCs and SVOCs are documented constituents of



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gasoline and oils. Based upon these results, it appears that leaks and spills from both former USTs have caused the existing soil contamination.

Subsurface soil contamination by these contaminants extends south from the waste oil UST excavation approximately 180 feet, and is a maximum of 110 feet wide (see Figures 7-1 through 7-8). Subsurface soil contamination does extend horizontally beyond the southwestern fenceline, however, the remaining soil contamination appears to be within the fenced area of AOC 43J. The majority of contaminated soil was detected at, or just below, the water table, at depths ranging from 7 to 12 feet bgs. Distribution of the subsurface soil contamination supports the USTs as source areas, and the observed groundwater flow direction in January and May 1995 (see Figure 6-5 and 6-6). Subsurface soil contamination was detected at higher concentrations at the water table, with decreasing concentrations as sample depth increased (see Table 7-9, soil boring data from XJB-94-03X, XJB-94-10X, XJB-94-11X, and XJB-94-12X). Based on soil boring data, it appears that contamination has not migrated vertically to the bedrock surface.

### 7.2.2 Groundwater

The following discussion of groundwater sampling includes field analytical results, and four rounds (Rounds Three, Four, Five, and Six) of off-site laboratory analytical results. However, the focus of this discussion will be on the 1994 RI sampling results because these rounds include all of the new and existing monitoring wells.

**7.2.2.1 Field Analytical Groundwater Results.** Groundwater samples were collected for field analysis during the 1994 RI field program, only. Groundwater samples were collected from 10 screened auger borings (SAJ01 through SAJ10) and analyzed for BTEX and selected chlorinated solvents (Table 7-10).

The field analytical results indicated that BTEX was present in samples collected from SAJ01, SAJ02, SAJ04, SAJ05, SAJ09, and SAJ10 located downgradient of the former UST excavations (see Table 7-10). Benzene was detected in six of 10 samples, with concentrations ranging from 3.8  $\mu\text{g/L}$  at SAJ01 to 460  $\mu\text{g/L}$  at SAJ04; toluene was detected in 3 of 10 samples, at concentrations ranging from 29  $\mu\text{g/L}$  at SAJ10 to 1,400  $\mu\text{g/L}$  at SAJ02; ethylbenzene was detected in 4 of 10

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samples, at concentrations ranging from 4.6  $\mu\text{g/L}$  at SAJ09 to 2,300  $\mu\text{g/L}$  at SAJ02; m/p-xylene was detected in 4 of 10 samples, at concentrations ranging from 4.5  $\mu\text{g/L}$  at SAJ09 to 1,800  $\mu\text{g/L}$  at SAJ02; o-xylene was detected in 5 of 10 samples, at concentrations ranging from 3.1  $\mu\text{g/L}$  at SAJ09 to 680  $\mu\text{g/L}$  at SAJ02. No chlorinated VOCs were detected in any screened auger samples.

Horizontal distribution of groundwater contamination evidenced in screened auger samples indicates groundwater contamination to the south, southeast, and east of the former UST excavations (see Figure 7-5). This distribution is in agreement with the interpretive groundwater flow directions for January 1995 and May 1995 (see Figures 6-5 and 6-6).

The results of the field analyses of screened auger samples were used to optimize locations of the new RI monitoring wells.

**7.2.2.2 Off-Site Groundwater Laboratory Analytical Sample Results.** Two rounds of off-site laboratory analytical samples were collected during the SSI (Rounds Three and Four) and RI (Rounds Five and Six) field investigations conducted at AOC 43J. Table 5-2 presents the samples collected, the field program, and the analyses requested. Table 7-11 presents analytes detected in pre-1994 and 1994 groundwater samples. No groundwater samples were collected by ABB-ES during the SI. The following discussion will focus quantitatively on RI data, and use the SSI data in a qualitative fashion. Inorganic analyte concentrations will be compared to Fort Devens groundwater background concentrations.

**UST Removal Groundwater Results.** As part of the 1992 waste oil UST removal, ATEC installed four monitoring wells (2446-01 through 2446-04) (Figure 7-5). Each of the ATEC monitoring wells were installed, at least partially, in the bedrock and ranged from 18 to 25 feet bgs. Boring logs and monitoring well installation diagrams for these wells are presented in Appendix A and C. ATEC sampled each of these wells once for TPHC, only. These samples were analyzed by a non-USAEC-certified laboratory. Therefore, these data will be considered USEPA Level II data quality. The results of these groundwater samples indicated that TPHC was present in the groundwater on the east-southeast side of the excavation. Concentrations of TPHC in groundwater ranged from below the detection limit in the apparent upgradient well (2446-01) to 140  $\mu\text{g/L}$  in 2446-03 (ATEC, 1992a) (see Table 7-11).

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**SSI Groundwater Results.** During the 1993 SSI field program, ABB-ES installed four groundwater monitoring wells to monitor groundwater quality upgradient and downgradient of both former USTs (see Figure 7-5). The well screen for each monitoring well was installed across the water table to monitor for floating contaminants. Two of the monitoring wells (XJM-93-02X and XJM-93-03X) were installed as overburden wells and the other two monitoring wells (XJM-93-01X and XJM-93-04X) were installed in the bedrock.

Two rounds (Rounds Three and Four) of groundwater samples were collected from the new and existing monitoring wells during the SSI. Round Three groundwater samples were collected in October 1993, and Round Four groundwater samples were collected in January 1994. All of the samples were submitted for off-site laboratory analysis (see Table 5-2).

The results of the Round Three and Four groundwater sampling indicated that several VOCs (including BTEX; 1,2-DCE; and 1,2-dichlorobenzene), SVOCs (2-methylnaphthalene, naphthalene and phenanthrene), and TPHC were present in groundwater at three of the newly installed downgradient monitoring wells (XJM-93-02X, XJM-93-03X, and XJM-93-04X), as well as in one, if not all of the existing downgradient monitoring wells (2446-02, 2446-03, and 2446-04) (see Table 7-11). Several inorganics were detected above their Fort Devens background concentrations in the unfiltered samples. Several inorganic analytes (arsenic, calcium, iron, magnesium, manganese, and sodium) were also detected above their Fort Devens background concentration in the filtered samples.

**RI Groundwater Results.** During the 1994 RI field program, ABB-ES installed six additional groundwater monitoring wells (XJM-94-05X through XJM-94-10X) to monitor groundwater quality downgradient and cross-gradient of both former UST excavations (Figure 7-6). The well screen in each of the monitoring wells was installed across the water table to monitor for floating fuel-related contaminants. Each new monitoring well, except XJM-94-07X, was installed in the till as an overburden monitoring well. XJM-94-07X was installed in what was later determined to be a boulder. However, the screened interval of XJM-94-07X maintains hydraulic connection with the water table found in the till.

Two rounds (Rounds Five and Six) of groundwater samples were collected from the new and existing monitoring wells during the RI. Round Five groundwater

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samples were collected in December 1994, and Round Six groundwater samples were collected in March 1995. All of the samples were submitted for off-site laboratory analysis (see Table 5-2).

The results of the Round Five and Six groundwater sampling indicated that several fuel-related and chlorinated solvents were present in the samples including BTEX, 1,2-dichloroethane, and carbon tetrachloride (see Table 7-11). Fuel-related VOCs were detected in monitoring wells 2446-02, 2446-03, 2446-04, XJM-93-02X, XJM-93-03X, XJM-94-05X, XJM-94-08X, and XJM-94-09X in both rounds of sampling. Acetone, chloroform, and methylene chloride were also detected in some samples, however these compounds appear to be attributable to laboratory contamination based on the QC program (see Table 7-11). These analytes are not considered to be site-related contaminants (see Subsection 7.1.2). Benzene was detected at concentrations ranging from 0.56  $\mu\text{g/L}$  (XJM-94-08X) to 300  $\mu\text{g/L}$  (XJM-94-05X) in both rounds. Ethylbenzene was detected at concentrations ranging from 0.92  $\mu\text{g/L}$  (XJM-94-09X) to 3,000  $\mu\text{g/L}$  (2446-02 and 2446-03). Toluene was detected at concentrations ranging from 0.73  $\mu\text{g/L}$  (XJM-94-08X) to 7,000  $\mu\text{g/L}$  (2446-02). Xylenes were detected at concentrations ranging from 8.0  $\mu\text{g/L}$  (XJM-93-02X) to 8,000  $\mu\text{g/L}$  (2446-02). Distribution and concentrations of BTEX are consistent with screened auger sample results and previous groundwater sampling data. The highest concentrations of BTEX were detected south and southeast of the former USTs, in monitoring wells 2446-02, 2446-03, and XJM-94-05X (see Table 7-11). Detection of VOC TICs and unknown compounds in groundwater samples is spatially consistent with detection of VOCs mentioned above and are consistent with fuel contamination (see Subsection 7.1.1).

Spatial distribution and concentrations of fuel-related VOCs is generally consistent with previous (SI and SSI) results, with the exception of concentrations detected in the bedrock monitoring well XJM-93-04X. Historically, XJM-93-04X contained fuel-related components (during Rounds Three and Four) since its initial sampling in 1993. However, concentrations decreased between Round Three and Four, and no fuel-related compounds were detected in this monitoring well during Round Five. However, Round Six data once again showed concentrations of fuel-related VOCs (BTEX). Seasonal fluctuations in groundwater elevation and observed flow direction are likely factors in the



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decrease and subsequent increase of concentrations of fuel-related compounds in this monitoring well.

1,2-dichloroethane was detected in monitoring well XJM-94-06X at a concentration of 23  $\mu\text{g/L}$  during Round Five and at 7.1  $\mu\text{g/L}$  in Round Six. 1,2-dichloroethane was not detected in any other wells at AOC 43J. The source of this chlorinated VOC appears to be the former waste oil UST.

Carbon tetrachloride was detected in the Round Six samples, only. Concentrations ranged from 3.3  $\mu\text{g/L}$  at XJM-94-09X to 100  $\mu\text{g/L}$  at XJM-94-05X (see Table 7-11). Several SVOCs (1,2-dichlorobenzene; 1,4-dichlorobenzene; 2,4-dimethylphenol; 2-methylnaphthalene; 2-methylphenol; 2-cresol; 4-cresol; and naphthalene) were detected during Rounds Five and Six. 1,2-dichlorobenzene was detected at concentrations ranging from 4.8  $\mu\text{g/L}$  at 2446-04 to 14.0  $\mu\text{g/L}$  at XJM-93-02X. 1,4-dichlorobenzene was detected at 3.6  $\mu\text{g/L}$  at XJM-93-02X, only. 2,4-dimethylphenol was only detected once at 8.8  $\mu\text{g/L}$  at XJM-93-05X. 2-methylnaphthalene was detected at concentrations ranging from 6.2  $\mu\text{g/L}$  at XJM-93-02X to 100.0  $\mu\text{g/L}$  in 2446-02. 2-methylphenol (2-cresol) was detected in 2446-02 and XJM-94-05X at 5.3 and 4.1  $\mu\text{g/L}$ , respectively. 4-methylphenol (4-cresol) was also detected in 2446-02, 2446-03, and XJM-93-05X at concentrations ranging from 2.0 to 3.9  $\mu\text{g/L}$ . Naphthalene was also detected in these two rounds, at concentrations ranging from 4.1  $\mu\text{g/L}$  at XJM-93-02X to 300  $\mu\text{g/L}$  at 2446-03 (see Table 7-11).

Each of the inorganic analytes on the PAL was detected above its established Fort Devens background concentration in either the Round Five or Round Six unfiltered sample results (see Table 7-11). The results of the filtered samples also showed inorganic analytes above their established Fort Devens background concentrations. These analytes included antimony, arsenic, calcium, iron, magnesium, manganese, potassium, sodium, and zinc. TSS concentrations ranged from 8,000  $\mu\text{g/L}$  in XJM-93-04X to 3,130,000  $\mu\text{g/L}$  at 2446-02 (see Table 7-11). Based on these concentrations and the inorganics detected in the filtered and unfiltered inorganic groundwater samples, it appears that a large portion of the inorganic analytes detected in the unfiltered samples are a result of TSS in the samples and not dissolved contaminants in groundwater.

**7.2.3.3 Summary of Groundwater Impacts.** Distribution and concentrations of VOCs detected in 1994 groundwater samples are in agreement with pre-1994 off-

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site laboratory data and the field analytical data. The distribution of the groundwater contamination appears to confirm that the past sources of groundwater contamination were the former historic gas station and waste oil USTs, and that the existing source of the groundwater contamination is the residual soil contamination at and directly downgradient of the former UST locations.

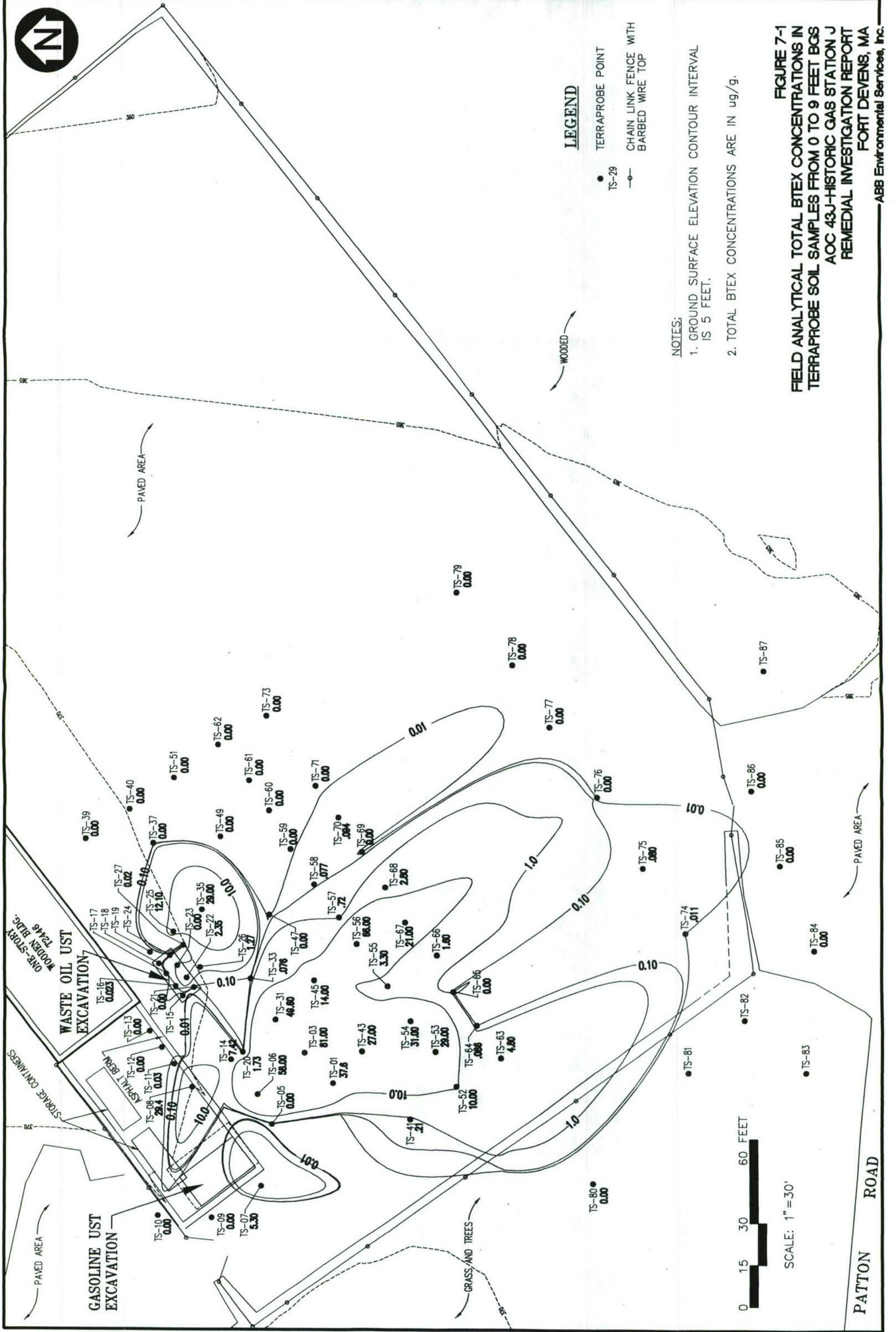
BTEX, chlorinated solvents, and several SVOCs were detected in several monitoring wells downgradient (2446-02, 2446-03, XJM-93-04X, XJM-94-05X, XJM-94-06X, and XJM-94-09X) of the former UST excavations.

Groundwater contaminant distribution is similar to soil contaminant distribution, except that low concentrations of fuel-related contaminants have been spread southeastward (toward XJM-94-08X) by seasonal fluctuations in groundwater flow direction (see Figures 7-5 and 7-6).

Although concentrations of inorganic analytes were generally above Fort Devens background concentrations in unfiltered samples, it appears that these results were caused by suspended solids rather than dissolved site-related contamination.

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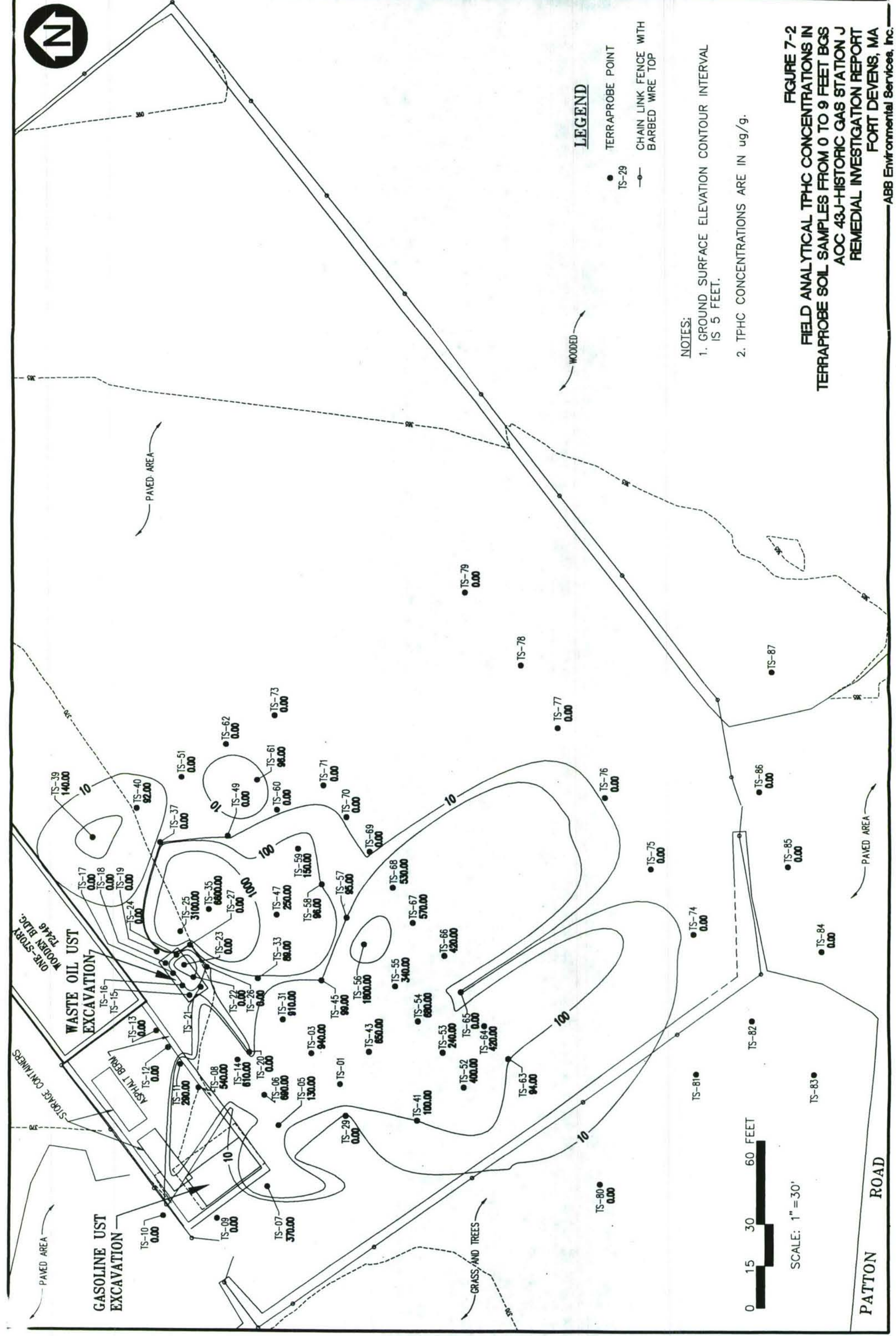




**FIGURE 7-1**  
**FIELD ANALYTICAL TOTAL BTX CONCENTRATIONS IN**  
**TERRAPROBE SOIL SAMPLES FROM 0 TO 9 FEET BGS**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**  
**ABB Environmental Services, Inc.**



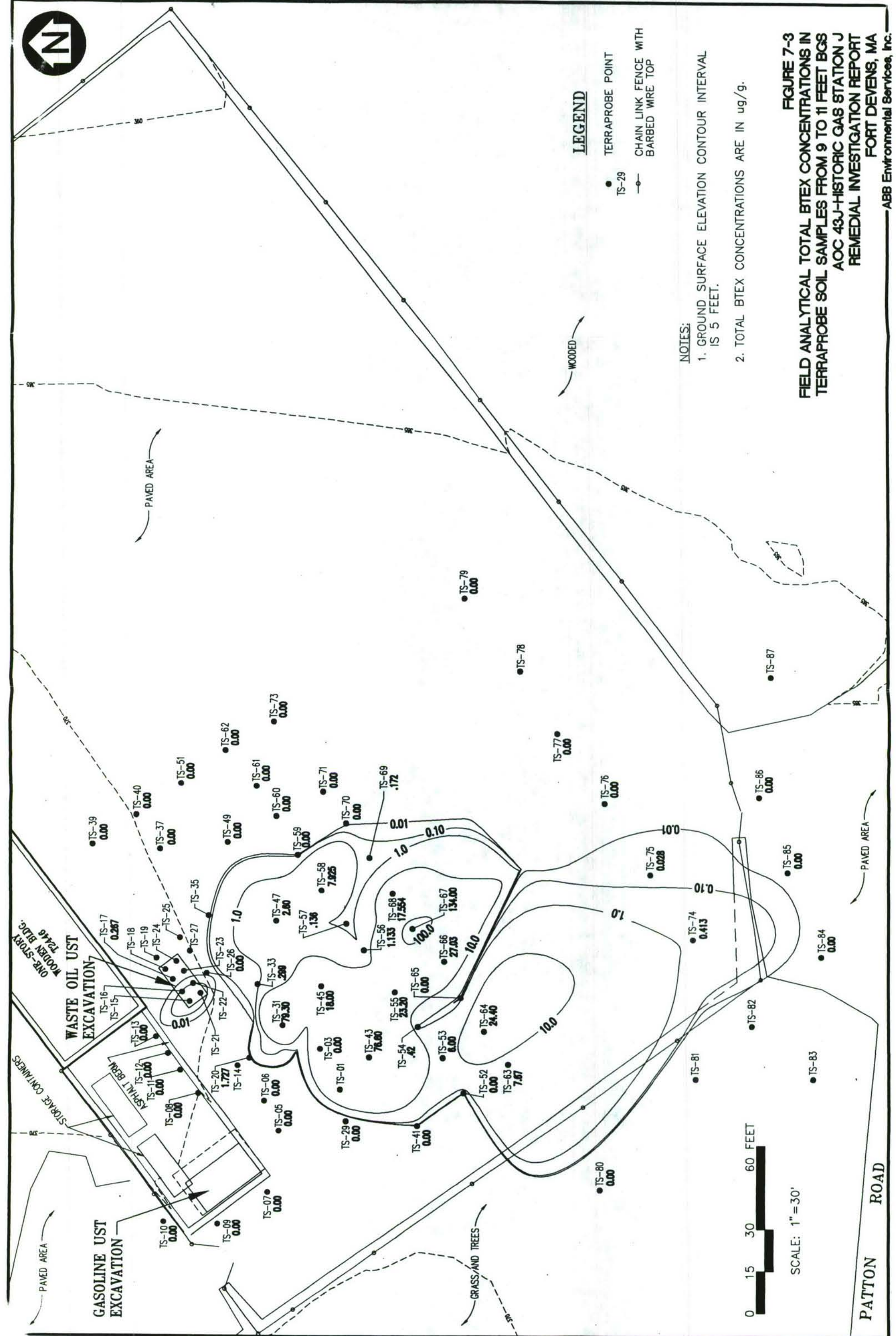




**FIGURE 7-2**  
**FIELD ANALYTICAL TPHC CONCENTRATIONS IN**  
**TERRAPROBE SOIL SAMPLES FROM 0 TO 9 FEET BGS**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**  
**ABB Environmental Services, Inc.**







LEGEND

- TERRAPROBE POINT
- CHAIN LINK FENCE WITH BARBED WIRE TOP

NOTES:

1. GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.
2. TOTAL BTEX CONCENTRATIONS ARE IN ug/g.

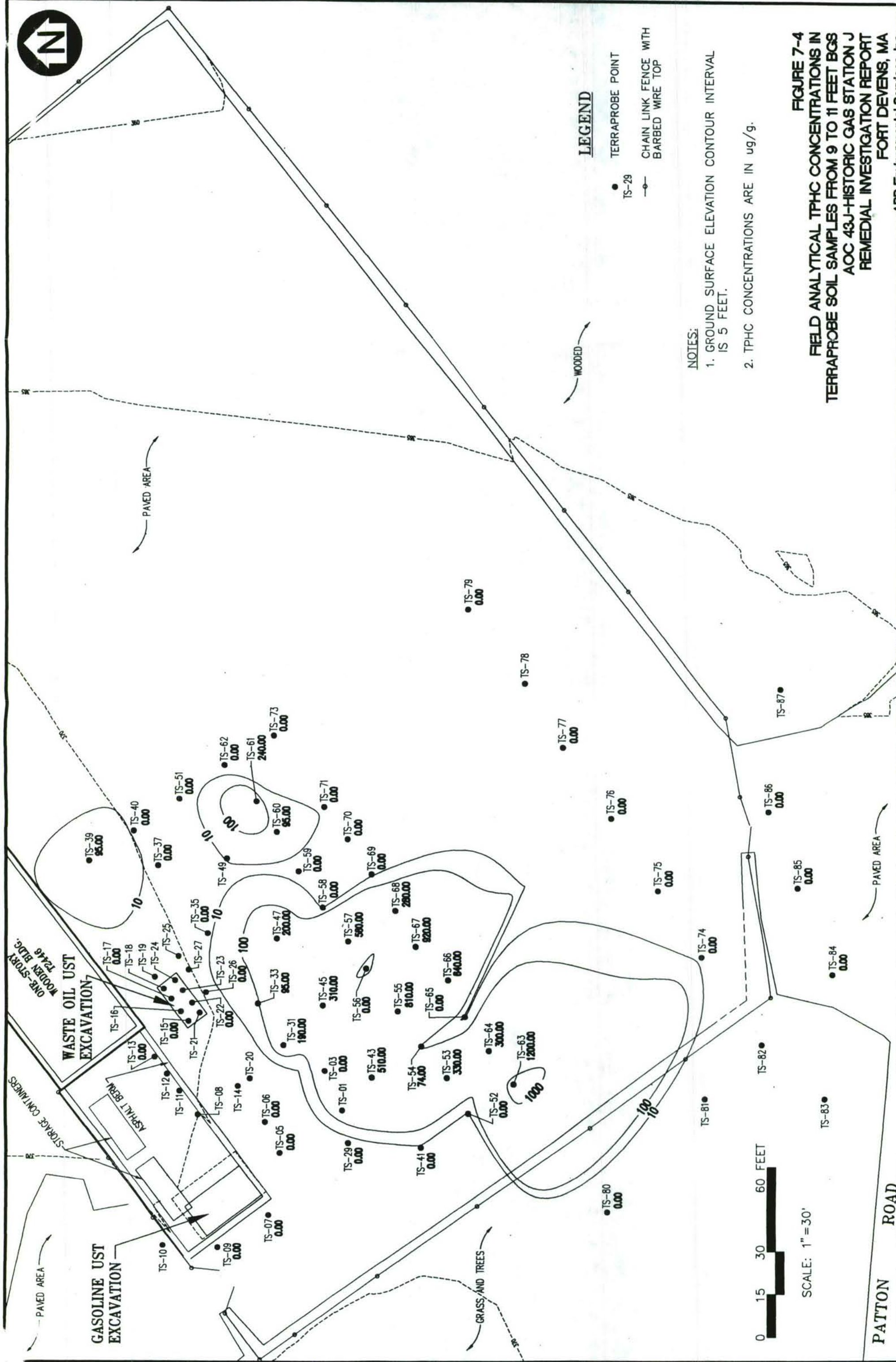
FIGURE 7-3  
FIELD ANALYTICAL TOTAL BTEX CONCENTRATIONS IN  
TERRAPROBE SOIL SAMPLES FROM 9 TO 11 FEET BGS  
AOC 43J-HISTORIC GAS STATION J  
REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MA  
ABB Environmental Services, Inc.



SCALE: 1" = 30'



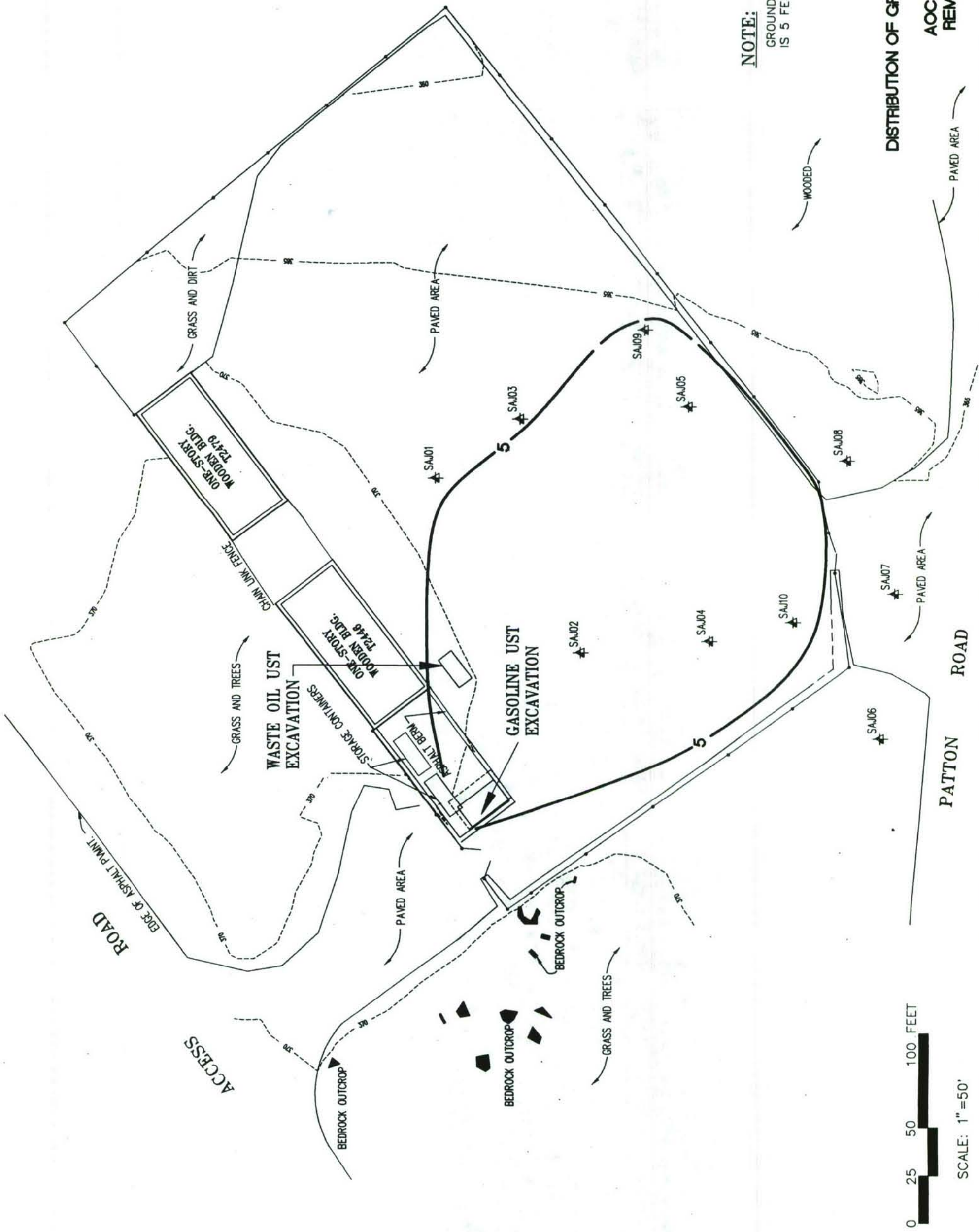




**FIGURE 7-4**  
**FIELD ANALYTICAL TPHC CONCENTRATIONS IN**  
**TERRAPROBE SOIL SAMPLES FROM 9 TO 11 FEET BGS**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIATION INVESTIGATION REPORT**  
**FORT DEVENS, MA**  
**ABB Environmental Services, Inc.**







**LEGEND**

- SAJ03 SCREENED AUGER
- CHAIN LINK FENCE WITH BARBED WIRE TOP
- 5 BENZENE CONCENTRATION ABOVE 5 ug/L

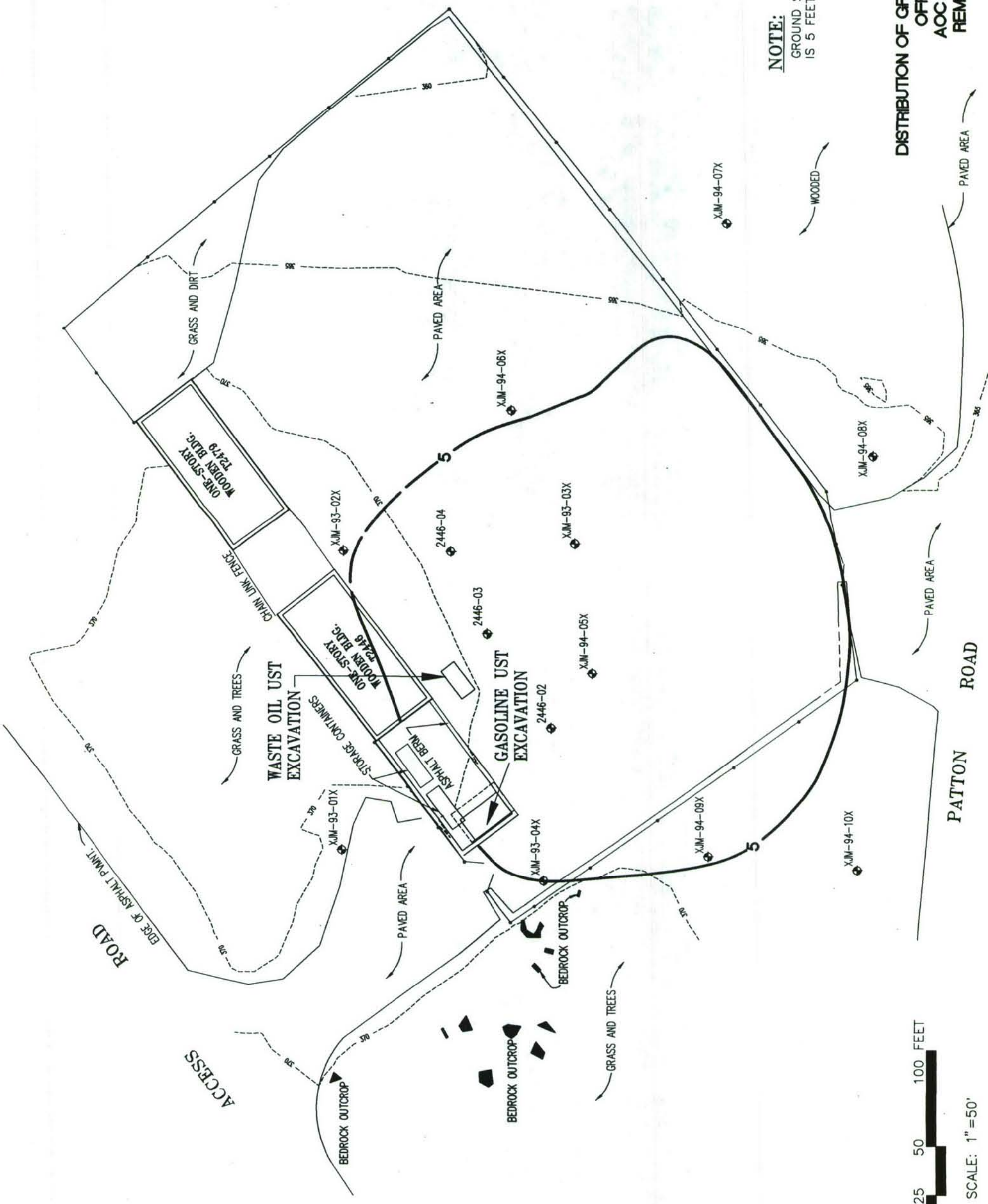
**NOTE:**

GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

**FIGURE 7-5**  
**DISTRIBUTION OF GROUNDWATER CONTAMINATION**  
**FIELD ANALYTICAL RESULTS**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIATION INVESTIGATION REPORT**  
**FORT DEVENS, MA**  
**ABB Environmental Services, Inc.**







**LEGEND**

- XJM-94-05X MONITORING WELL
- CHAIN LINK FENCE WITH BARBED WIRE TOP
- 5 BENZENE CONCENTRATION ABOVE 5 ug/L

**NOTE:**

GROUND SURFACE ELEVATION CONTOUR INTERVAL IS 5 FEET.

**FIGURE 7-6**  
**DISTRIBUTION OF GROUNDWATER CONTAMINATION**  
**OFF-SITE LABORATORY RESULTS**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIATION INVESTIGATION REPORT**  
**FORT DEVENS, MA**  
**ABB Environmental Services, Inc.**

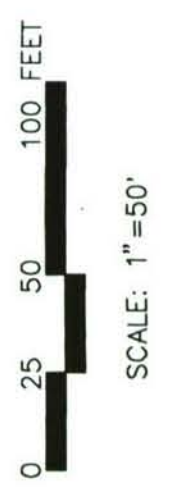






TABLE 7-1  
SUMMARY OF TICs AND UNKNOWN COMPOUNDS DETECTED IN SOIL BORING SAMPLES  
AOC 43J - HISTORIC GAS STATION J

REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

Site ID	43J-92-01X 5 ft BX43J105	XJB-94-02X 5 ft BXXJO205	XJB-94-02X 7 ft BXXJO207	XJB-94-03X 11 ft BXXJO311	XJB-94-03X 15 ft BXXJO315	XJB-94-04X 10 ft BXXJO410	XJB-94-06X 12 ft BXXJO612	XJB-94-06X 15 ft BXXJO615	XJB-94-08X 7 ft BXXJO807
Depth									
Field Sample Number									
PAL SEMIVOLATILE ORGANICS (µg/g)									
c22h40o Unknown		.32 S	.44 S	.56 S					.56 S
m-Xylene				1.1 S					
1-Methylnaphthalene									
o-Xylene				.56 S					
1,3,5-Trimethylbenzene									
p-Xylene									
1-Ethyl-2-methylbenzene				3.4 S			.22 S		
2,6,10,14-Tetramethylpentadecane		.32 S	.44 S	.45 S					
2-Ethyl-1-hexanol									
m-Propyltoluene									
4,7-Dimethylindan									
Tridecane									
Tricosane		.43 S	.55 S	.67 S			.33 S		.45 S
Octane				1.1 S	.0065 S				
Nonane				2.2 S	.0065 S				10 S
Decahydro-2-methylnaphthalene									
Ethylbenzene									
Indan				1.1 S					
Isodurene				.45 S					
n-Propylbenzene				.56 S					
Molecular sulfur				.67 S		.97 S			
Eicosane		.32 S	.44 S	.45 S					
Heptadecane		.54 S	.66 S	.78 S					
Nonadecane		.43 S	.66 S	.78 S					
Octadecane		.54 S	.66 S	.78 S					
Pentacosane		.86 S	1.1 S	1.1 S					
p-Cymene			.11 S						
Tetracosane		.43 S	.66 S	.78 S					.34 S
1,2,3-Trimethylbenzene							.33 S		
1,2,4-Trimethylbenzene							.33 S		
Decane			.099 S		.0065 S				
Undecane			.22 S	1.1 S	.0044 S				
Dodecane					.0065 S		.77 S		
Methylcyclohexane	.0042 S			20 S					





TABLE 7-1  
SUMMARY OF TICs AND UNKNOWN COMPOUNDS DETECTED IN SOIL BORING SAMPLES  
AOC 43J - HISTORIC GAS STATION J

REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

Site ID:	43J-92-01X 5 ft BX43J105	XJB-94-02X 5 ft BX43J0205	XJB-94-02X 7 ft BX43J0207	XJB-94-03X 11 ft BX43J0311	XJB-94-03X 15 ft BX43J0315	XJB-94-04X 10 ft BX43J0410	XJB-94-06X 12 ft BX43J0612	XJB-94-06X 15 ft BX43J0615	XJB-94-08X 7 ft BX43J0807
Depth:									
Field Sample Number:									
PAL VOLATILE ORGANICS (µg/g)									
m-Cymene			.11 S	30 S			.055 S		10 S
2-Methylpentane				20 S			.44 S		20 S
2-Methylheptane									
Isoheptane									
3,7-Dimethylnonane			.088 S						10 S
3-Methylhexane				20 S	.0033 S		.55 S		2 S
3-Methylpentane				30 S			.044 S		10 S
Heptane									
Hexane									
Pentane									
Methylcyclopentane				20 S					
UNKNOWN GC/MS TIC (µg/g)									
UNK091									
UNK106							.05 S		
UNK114									
UNK115					.007 S				
UNK116									
UNK128									
UNK160									10 S
UNK161									
UNK162									
UNK167									
UNK173									
UNK176									
UNK177			.2 S						
UNK182									
UNK183									
UNK184									
UNK186			.1 S						
UNK191			.1 S						
UNK192									
UNK194			.1 S						
UNK200				20 S					10 S
UNK201			.1 S						
UNK210									
UNK211				30 S					
UNK521				.3 S					20 S
UNK525				.3 S					





TABLE 7-1  
SUMMARY OF TICs AND UNKNOWN COMPOUNDS DETECTED IN SOIL BORING SAMPLES  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

Site ID:	43J-92-01X	XJB-94-02X	XJB-94-02X	XJB-94-03X	XJB-94-04X	XJB-94-06X	XJB-94-06X	XJB-94-06X
Depth:	5 ft	5 ft	7 ft	11 ft	10 ft	12 ft	15 ft	7 ft
Field Sample Number:	BX43J105	BX43J0205	BX43J0207	BX43J0311	BX43J0410	BX43J0612	BX43J0615	BX43J0807
UNKNOWN GC/MS TIC ( $\mu\text{g/g}$ ) (cont.)								
UNK526				.6 S				
UNK534				.3 S				
UNK535				.6 S				
UNK538				.8 S				
UNK540				1 S				
UNK541				4 S				
UNK543				9 S				
UNK544				.6 S				
UNK546				2 S				
UNK547				9 S				
UNK548				1 S				
UNK549				.7 S				
UNK550				1 S				
UNK551								
UNK553				.7 S				
UNK554				.8 S				
UNK555				.8 S				
UNK556				.6 S				
UNK557								
UNK558								
UNK559								
UNK560								
UNK561				.3 S				
UNK562								
UNK564								
UNK590								
UNK612	1 S		1 S	3 S				
UNK615	.4 S		.7 S	1 S				
UNK633				.9 S				
UNK634								
UNK645								
UNK658							2 S	

NOTES:  
S = Non-target compound analyzed for and detected  
? = Control chart either not received or not yet approved  
by USAEC





TABLE 7-1  
SUMMARY OF TICs AND UNKNOWN COMPOUNDS DETECTED IN SOIL BORING SAMPLES  
AOC 43J - HISTORIC GAS STATION J

REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

Site ID	XJB-94-08X 9 ft EXXJ0809	XJB-94-09X 9 ft EXXJ0909	XJB-94-10X 7 ft EXXJ1007	XJB-94-11X 7 ft EXXJ1107	XJB-94-11X 11 ft EXXJ1111	XJB-94-12X 11 ft EXXJ1211	XJB-94-13X 9 ft EXXJ1309	XJB-94-16X 20 ft EXXJ1620	XJM-93-02X 5 ft EXXJ0205
Depth									
Field Sample Number									
PAL SEMIVOLATILE ORGANICS (µg/g)									
c22h40o Unknown									
m-Xylene				2 S					
1-Methylnaphthalene	.59 S								
o-Xylene	.59 S								
1,3,5-Trimethylbenzene	1.2 S				.92 S				
p-Xylene	1.2 S			2 S	.92 S				
1-Ethyl-2-methylbenzene									
2,6,10,14-Tetramethylpentadecane									
2-Ethyl-1-hexanol	.82 S			5 S	.81 S				
m-Propyltoluene				4 S					
4,7-Dimethylindan				3 S					
Tridecane				3 S					
Tricosane									
Octane	.47 S			10 S?	.46 S	.35 S		.0066 S	
Nonane	.7 S			9 S?		.35 S		.0077 S	
Decahydro-2-methylnaphthalene									
Ethylbenzene	.94 S			1 S	.69 S				
Indan	.35 S			1 S					
Isodurene				5 S	.35 S				
n-Propylbenzene	.35 S								
Molecular sulfur									
Eicosane									
Heptadecane									
Nonadecane									
Octadecane									
Pentacosane									
p-Cymene				10 S					
Tetracosane									
1,2,3-Trimethylbenzene	.7 S			3 S	.46 S				
1,2,4-Trimethylbenzene	2.3 S			5 S	2.3 S				
Decane						.23 S			
Heptadecane						.12 S			
Dodecane									
Methylcyclohexane						.12 S			





TABLE 7-1  
SUMMARY OF TICs AND UNKNOWN COMPOUNDS DETECTED IN SOIL BORING SAMPLES  
AOC 43J - HISTORIC GAS STATION J

REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

Site ID: Depth: Field Sample Number:	XJB-94-08X 9 ft BXXJ0809	XJB-94-09X 9 ft BXXJ0909	XJB-94-10X 7 ft BXXJ1007	XJB-94-11X 7 ft BXXJ1107	XJB-94-11X 11 ft BXXJ1111	XJB-94-12X 11 ft BXXJ1211	XJB-94-13X 9 ft BXXJ1309	XJB-94-16X 20 ft BXXJ1620	XJM-93-02X 5 ft BXXJ0205
PAL VOLATILE ORGANICS (µg/g)									
m-Cymene	20 S			20 S?	30 S	.23 S			
2-Methylpentane	50 S			20 S?	20 S				
2-Methylheptane	50 S								
Isoheptane									
3,7-Dimethylnonane	20 S			10 S?	10 S				
3-Methylhexane					10 S				
3-Methylpentane	70 S			20 S?	20 S	.12 S			
Heptane	50 S				30 S				
Hexane					10 S				
Pentane	20 S				20 S				
Methylcyclopentane									
UNKNOWN GC/MS TIC (µg/g)									
UNK091									
UNK106			.4 S	30 S?		.1 S		.007 S	
UNK114			.5 S					.007 S	
UNK115			.8 S						
UNK116			.3 S						
UNK128			.7 S						
UNK160	50 S		.7 S						
UNK161			.4 S						
UNK162									
UNK167									
UNK173									
UNK176									
UNK177									
UNK182									
UNK183									
UNK184			.3 S						
UNK186			.3 S						
UNK191			.1 S						
UNK192									
UNK194									
UNK200									
UNK201	20 S			10 S?					
UNK210									
UNK211	20 S			20 S?	10 S	.1 S		.01 S	
UNK521								.006 S	
UNK525									





TABLE 7-1  
SUMMARY OF TICs AND UNKNOWN COMPOUNDS DETECTED IN SOIL BORING SAMPLES  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

Site ID: Depth: Field Sample Number: UNKNOWN GC/MS TIC ( $\mu\text{g/g}$ ) (cont.)	XJB-94-08X 9 ft BXXJ0809	XJB-94-09X 9 ft BXXJ0909	XJB-94-10X 7 ft BXXJ1007	XJB-94-11X 7 ft BXXJ1107	XJB-94-11X 11 ft BXXJ1111	XJB-94-12X 11 ft BXXJ1211	XJB-94-13X 9 ft BXXJ1309	XJB-94-16X 20 ft BXXJ1620	XJM-93-02X 5 ft BXXJ0205
UNK526									
UNK534					.5 S				
UNK535									
UNK538									
UNK540									
UNK541									
UNK543									
UNK544									
UNK546									
UNK547	1 S			2 S	1 S				
UNK548	.6 S			2 S	.6 S				
UNK549									
UNK550									
UNK551	.4 S			3 S					
UNK553	.5 S			5 S	.5 S				
UNK554	.5 S			5 S	.6 S				
UNK555				2 S					
UNK556				2 S					
UNK557				2 S					
UNK558				2 S	.3 S				
UNK559				2 S					
UNK560				1 S					
UNK561				2 S					
UNK562				3 S	.3 S				
UNK564				2 S					
UNK590									
UNK612									
UNK615									
UNK633									
UNK634							2 S		
UNK645									
UNK658		.3 S							.8 S

NOTES:  
S = Non-target compound analyzed for and detected  
? = Control chart either not received or not yet approved  
by USAEC









TABLE 7-1  
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER SAMPLES  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number:	2446-02 10/04/93 10 MX4402X1	2446-02 01/27/94 10 MX4402X2	2446-02 12/06/94 0 MX4402X3	2446-02 12/06/94 14.7 MX4402X4	2446-02 03/21/95 14.7 MX4402X5	2446-03 10/04/93 13 MD4403X1	2446-03 10/04/93 13 MX4403X1	2446-03 01/27/94 13 MX4403X2	2446-03 12/06/94 0 MX4403X3	2446-03 12/06/94 17.7 MX4403X4	2446-03 03/20/95 17.7 MX4403X5
Unk532	900					1000	S				
Unk536											
Unk537											
Unk540											
Unk541											
Unk542											
Unk544											
Unk546											
Unk547	300	500	S			200	S	60	S		
Unk548	400	400	S			500	S	200	S		
Unk549	400	700	S			800	S	300	S		
Unk550	1000	300	S			500	S	100	S		
Unk551	500					1000	S	300	S		
Unk552		200	S		10000	500	S	70	S		6000
Unk553	100					500	S	200	S		
Unk554	200					800	S	200	S		
Unk555	400					500	S	200	S		
Unk556	200					500	S	200	S		
Unk557											
Unk558	40	90	S			200	S	80	S		
Unk559	40	100	S			200	S	200	S		
Unk560	50	300	S			200	S	70	S		
Unk561	80										
Unk562											
Unk564											
Unk565											
Unk566											
Unk567											
Unk568											
Unk570											
Unk571											
Unk572											
Unk573											
Unk574											
Unk576											
Unk577											
Unk578											
Unk579											
Unk580											
Unk581											
Unk582											
Unk583											
Unk598											
Unk602											
Unk614											
Unk615											
Unk616											
Unk617											
Unk618											
Unk619											
Unk620											
Unk622											
Unk644											
Unk645											
Unk652											
Unk662											

Notes:  
R = non-target compound analyzed for but not detected.  
S = non-target compound analyzed for and detected.  
I = interferences in sample cause quantitation or identification to be suspect.





TABLE 7-1  
SUMMARY OF TICs AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER SAMPLES  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA[illegible]





TABLE 7-1  
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER SAMPLES  
AOC 43J - HISTORIC GAS STATION J

REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number:	2446-04 01/27/94 15 MD4604X1	2446-04 01/27/94 15 MX4603X2	2446-04 10/04/93 15 MX4604X1	2446-04 12/09/94 19.5 MX4604X3	2446-04 03/28/95 19.5 MX4604X4	2446-04 10/04/93 15 MX4604X5	2446-04 12/02/94 10.9 MDX402X3	2446-04 10/07/93 10.9 MX4603X1	2446-04 01/25/94 10.9 MX4603X2	2446-04 12/02/94 10.9 MX4603X3	2446-04 03/21/95 10.9 MX4603X4
Unit532			100	S				S			S
Unit536											
Unit537											
Unit540											
Unit541											
Unit542											
Unit544											
Unit546											
Unit547											
Unit548											
Unit549											
Unit550											
Unit551											
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Unit579											
Unit580											
Unit581											
Unit582											
Unit583											
Unit588											
Unit602											
Unit614											
Unit615											
Unit616											
Unit617											
Unit618											
Unit619											
Unit620											
Unit622											
Unit644											
Unit645											
Unit652											
Unit662											

Notes:  
R = non-target compound analyzed for but not detected.  
S = non-target compound analyzed for and detected  
I = interferences in sample cause quantitation or identification to be suspect.



TABLE 7-1  
SUMMARY OF TICs AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER SAMPLES  
AOC 43J - HISTORIC GAS STATION J

**REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA**

[illegible]





TABLE 7-1  
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER SAMPLES  
AOC 43J - HISTORIC GAS STATION J  
REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number:	XJM-51-43X 10/07/93 11.5 MXCJ03X1	XJM-51-43X 10/15/93 11.5 MXCJ03X1	XJM-51-43X 01/27/94 11.5 MXCJ03X2	XJM-51-43X 12/08/94 16.1 MXCJ03X3	XJM-51-43X 03/21/95 16.1 MXCJ03X4	XJM-51-43X 10/07/93 9.2 MXCJ03X1	XJM-51-43X 02/02/94 9.2 MXCJ04X1	XJM-51-43X 03/21/95 13.8 MXCJ04X4	XJM-51-43X 12/02/94 0 MXCJ04X3	XJM-51-43X 12/02/94 14.9 MXCJ04X3	XJM-51-43X 03/21/95 14.9 MXCJ04X4
Unit 532			10 S					7 S		40 S	
Unit 536		40 S	10 S			200 S					
Unit 537		10 S	10 S			200 S					
Unit 540											
Unit 541		30 S									
Unit 542											
Unit 544		10 S									
Unit 546											
Unit 547		9 S	30 S			20 S		10 S		300 S	
Unit 548		8 S	20 S			60 S		10 S		9 S	
Unit 549			10 S			20 S		10 S		4 S	
Unit 550						10 S				5 S	
Unit 551						20 S					
Unit 552		8 S				30 S		5 S			
Unit 553		20 S				60 S		8 S			
Unit 554						40 S		10 S			
Unit 555						20 S		20 S			
Unit 556						10 S		40 S			
Unit 557						30 S		90 S			
Unit 558		10 S	9 S			60 S		20 S		30 S	
Unit 559			9 S					10 S		40 S	
Unit 560			30 S					10 S		20 S	
Unit 561								30 S		100 S	
Unit 562								10 S		20 S	
Unit 564								10 S		20 S	
Unit 565								10 S		20 S	
Unit 566								10 S		20 S	
Unit 567								30 S		40 S	
Unit 568										70 S	
Unit 570											
Unit 571											
Unit 572											
Unit 573											
Unit 574											
Unit 576											
Unit 577											
Unit 578											
Unit 579											
Unit 580											
Unit 581											
Unit 582											
Unit 583											
Unit 598											
Unit 602											
Unit 614											
Unit 615											
Unit 616											
Unit 617											
Unit 618											
Unit 619											
Unit 620											
Unit 622											
Unit 644											
Unit 645											
Unit 652											
Unit 662											

Notes:  
R = non-target compound analyzed for but not detected.  
S = non-target compound analyzed for and detected.  
I = interferences in sample cause quantitation or identification to be suspect.





TABLE 7-1  
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER SAMPLES  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number:	XJM-94-66X 12/02/94 0 MXCJ06X3	XJM-94-66X 12/02/94 16.2 MXCJ06X3	XJM-94-66X 03/21/95 16.2 MXCJ06X4	XJM-94-68X 11/10/94 17.5 MXCJ08X3	XJM-94-69X 12/01/94 19 MXCJ09X3	XJM-94-69X 03/21/95 19 MXCJ09X4	XJM-94-10X 11/08/94 31.5 MXCJ10X3	XJM-94-10X 12/01/94 18 MXCJ10X3	XJM-94-10X 03/21/95 18 MXCJ10X4
PAL SEMIVOLATILE ORGANICS (µg/L)									
1234mb									
1,2,3-trimethylbenzene									
12dmb									
135mb									
134eb									
1,3-dimethylbenzene / M-xylene									
14dmb									
16dmb									
16dmb									
162mb									
1-methylbiphenyl									
23dmb									
3mchx									
3pt									
Bzodhp									
Cl16a									
Cl19									
Cl20									
Cl21									
Cl16be									
Cpo									
Etcmhz									
Et4mbz									
Et6b5									
Indan									
Indene									
Isodur									
Isophz									
Mec6b5									
Mibk									
Preb5									
Trmbz									
200									
PAL PESTICIDES/PCBS (µg/L)									
2-methylpentane									
PAL VOLATILE ORGANICS (µg/L)									
*dichloro Benzenes									
2mb									
Zmb3									
Zmb4									
3mepn									
Amylen									
CA									
Cytx									
Cytxe									
Hexane									
Mesotype									
Penlan									
UNKNOWN COMS TIC (µg/L)									
Unk036									
Unk046									
Unk047									
Unk087									
Unk088									
Unk098									
Unk120									
Unk239									
Unk521									
Unk522									
Unk527									
Unk531									



TABLE 7-1  
SUMMARY OF TICS AND UNKNOWN COMPOUNDS DETECTED IN GROUNDWATER SAMPLES  
AOC 43J - HISTORIC GAS STATION J

REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number:	XJM-94-06X 12/02/94 0 MCCJ06X3	XJM-94-06X 12/02/94 16.2 MCCJ06X3	XJM-94-06X 03/21/95 16.2 MCCJ06X4	XJM-94-06X 11/20/94 17.5 MCCJ06X3	XJM-94-09X 12/01/94 19 MCCJ09X3	XJM-94-09X 03/21/95 19 MCCJ09X4	XJM-94-10X 11/20/94 31.5 MCCJ10X3	XJM-94-10X 12/01/94 18 MCCJ10X3	XJM-94-10X 03/21/95 18 MCCJ10X3
Unk532			S				7 6 S		
Unk536									
Unk537					10 S				
Unk540									
Unk541				8 S	10 S		5 S		
Unk542					10 S				
Unk544					10 S				
Unk546					20 S		20 60 S		
Unk547									
Unk548									
Unk549									
Unk550									
Unk551									
Unk552									
Unk553									
Unk554									
Unk555									
Unk556									
Unk557									
Unk558									
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Unk562									
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Unk565									
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Unk567									
Unk568									
Unk570									
Unk571									
Unk572									
Unk573									
Unk574									
Unk576									
Unk577									
Unk578									
Unk579									
Unk580									
Unk581									
Unk582									
Unk583									
Unk598									
Unk602									
Unk614									
Unk615									
Unk616									
Unk617									
Unk618									
Unk619									
Unk620									
Unk622									
Unk644									
Unk645									
Unk652									
Unk662									

Notes:  
R = non-target compound analyzed for but not detected  
S = non-target compound analyzed for and detected  
I = interferences in sample cause quantitation or identification to be suspect





**TABLE 7-2**  
**SUMMARY OF ANALYTES DETECTED IN METHOD BLANKS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Analyte	Frequency of Detection	Minimum Detection	Maximum Detection
<b>Soil <math>\mu\text{g/g}</math></b>			
<b>VOCs</b>			
Toluene	1:27	0.00095	0.00095
Trifluorochloromethane	5:27	0.0063	0.01
Xylene	2:27	0.0019	0.014
Acetone	1:27	0.027	0.027
Chloroform	2:27	0.001	0.002
<b>SVOCs</b>			
Bis(2-ethylhexyl)phthalate	2:18	0.64	2.2
4-Methyl-3-penten-2-one	2:11	0.5	0.5
Di-N-Butyl Phthalate	5:18	0.09	40
<b>Pesticides/PCBs</b>			
a-Chlordane	1:5	0.006	0.006
g-Chlordane	1:5	0.041	0.041
Heptachlor	1:5	0.032	0.032
<b>Aqueous <math>\mu\text{g/L}</math></b>			
<b>VOCs</b>			
Toluene	1:32	0.51	0.51
Methylene Chloride	4:32	4.6	9.1
Chloroform	3:32	0.91	1.1
Acetone	3:32	16	53
Methyl Ethyl Ketone	1:32	9.5	9.5
<b>SVOCs</b>			
Bis(2-ethylhexyl)phthalate	5:19	5.6	200
1,2-Epoxy cyclohexane	4:19	1.0	4.0
2-Cyclohexen-1-ol	1:19	3.0	3.0
2-Cyclohexen-1-one	1:19	4.0	4.0
Mesityl Oxide	1:19	2.0	2.0
<b>Inorganics</b>			
Iron	1:15	56	56
Lead	1:15	3.2	3.2
<b>Miscellaneous</b>			
Hardness	2:6	1200	1600
TDS	2:6	11000	12000
TSS	4:14	4000	7000





**TABLE 7-3**  
**EQUIPMENT RINSATE SUMMARY**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Analyses	Frequency of Detection	Minimum Detection	Maximum Detection
<b>VOCs</b>			
1,1,1-Trichloroethane	4:6	1.8	6.8
Acetone	1:6	18	18
Methylene Chloride	2:6	2.8	4.0
Chloroform	1:6	1.3	1.3
<b>SVOCs</b>			
Di-n-butyl Phthalate	2:3	9.1	13
<b>Inorganics</b>			
Lead	3:7	1.52	3.4
Aluminum	1:5	499	499
Iron	2:5	48	1120
Manganese	2:5	3.5	30.2
Arsenic	1:5	3.8	3.8
Calcium	1:5	4790	4790
Potassium	1:5	488	488
<b>Miscellaneous</b>			
TOC	1:3	1340	1340

Notes:

VOCs = Volatile Organic Carbon  
SVOC = Semivolatile Organic Carbon  
TPH = Total Petroleum Hydrocarbons  
All result ug/L



**TABLE 7-4**  
**TRIP BLANK SUMMARY**  
**AOC 43J - HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Analyses	Frequency of Detection	Minimum Detection	Maximum Detection
<b>VOCs</b>			
Total Xylenes	1:42	1.9	1.9
Acetone	1:42	29	29
Methylene Chloride	8:42	2.6	17
Chloroform	1:42	0.81	0.81

Notes:

VOCs = Volatile Organic Carbon  
SVOC = Semivolatile Organic Carbon  
TPH = Total Petroleum Hydrocarbons  
All result  $\mu\text{g/L}$





**TABLE 7-5**  
**ATEC FIELD SCREENING/LABORATORY RESULTS**  
**AOC 43J HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

SAMPLE NO.	FIELD SCREENING		LABORATORY	
	PID (ppm)	NDIR μg/g	VOC* μg/g	TPH μg/g
<b>1000-gal. Waste Oil UST Excavation</b>				
SS-1	8.4	39.3	NA	NA
SS-2	5.2	16.4	NA	NA
SS-3	8.2	12.8	NA	NA
SS-4	0.8	15.8	NA	NA
SS-5	16.8	213.8	NA	NA
SS-6	6.6	90.2	NA	NA
SS-7	ND	20.5	NA	NA
SS-8	0.2	11.5	NA	NA
SS-9	5.6	864.9	NA	NA
SS-10	0.8	16.9	NA	NA
LSS-1	NA	NA	NA	74
LSS-2	NA	NA	NA	918
<b>5000-gal. Historic Gas Station UST Excavation</b>				
SS-1	350.0	759.9	NA	NA
SS-2	400.0	315.6	NA	NA
SS-3	200.0	43.9	NA	NA
SS-4	150.0	189.5	NA	NA
SS-5	100.0	3122	NA	NA
SS-6	100.0	3534.8	NA	NA
SS-7	300.0	469.2	NA	NA
SS-8	290.0	659.8	NA	NA
LRS-1	6.0	NA	NA	NA
LRS-2	7.0	NA	NA	NA
LRS-3	170.0	NA	2.2	NA
LRS-4	180.0	NA	NA	2170
LSS-1	NA	NA	0.572	1660
LWS-1	NA	NA	0.132	114

**NOTES:**

\* = total VOCs detected

SS = ATEC Field Screening Sample

LRS = ATEC Laboratory Remedial Soil Sample

LSS = ATEC Laboratory Soil Sample

LWS = ATEC Laboratory Water Sample (Water Sample from the Excavation)

Stock = Soil Stock Pile Sample

ND = Non-detect

NA = Not analyzed





TABLE 7-6  
SI AND SSI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE		SI								
		TS-01 4 ft	TS-01 9 ft	TS-03 9 ft	TS-05 3 ft	TS-06 8 ft	TS-07 3 ft	TS-08 8 ft	TS-09 3 ft	TS-10 3 ft
ORGANICS (µg/g)										
Benzene		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Toluene		0.710	0.770	17.000	<0.005	3.400	<0.005	<0.005	<0.005	<0.005
Ethylbenzene		3.300	0.570	16.000	<0.010	15.000	<0.010	5.400	<0.010	<0.010
m/p-xylene		20.000	2.000	30.000	<0.005	29.000	5.300	13.000	<0.005	<0.005
o-xylene		10.000	0.260	18.000	<0.005	11.000	ND	11.000	ND	ND
OTHER (µg/g)										
Total Petroleum Hydrocarbons		NR	270	940	130	690	370	540	< 55	< 55

**Notes:**

< = Less than detection limit.

NR = Not Requested



TABLE 7-6  
SI AND SSI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE		SSI								
		TS-11 8 ft	TS-12 8 ft	TS-13 8 ft	TS-14 8 ft	TS-16 8 ft	TS-17 8 ft	TS-17 9 ft	TS-18 8 ft	TS-19 8 ft
ORGANICS (µg/g)										
Benzene		<0.0001	<0.0001	<0.0001	< 0.050	< 0.0005	<0.0001	< 0.0002	<0.0001	<0.0001
Toluene		0.0041	<0.0001	<0.0001	1.900	< 0.0005	<0.0001	0.031	<0.0001	<0.0001
Ethylbenzene		0.0087	<0.0001	<0.0001	1.800	< 0.0005	<0.0001	0.083	<0.0001	<0.0001
m/p-xylene		0.015	<0.0001	<0.0001	3.200	0.010	0.001	0.110	0.0009	<0.0001
o-xylene		0.0056	<0.0001	<0.0001	0.520	0.013	0.0008	0.043	<0.0001	<0.0001
OTHER (µg/g)										
Total Petroleum Hydrocarbons		290	< 56	< 54	610	< 55	< 53	< 54	< 55	< 54

**Notes:**

< = Less than detection limit.

NR = Not Requested





TABLE 7-6  
SI AND SSI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE	SSI						
	TS-20 8 ft	TS-22 8 ft	TS-23 8 ft	TS-24 8 ft	TS-25 8 ft	TS-26 8 ft	TS-27 8 ft
ORGANICS (µg/g)							
Benzene	<0.0003	< 0.068	<0.014	< 0.0001	< 0.130	< 0.055	< 0.0006
Toluene	0.077	< 0.068	<0.014	< 0.0001	< 0.130	< 0.055	0.0072
Ethylbenzene	0.490	< 0.068	0.360	< 0.0001	2.400	0.450	< 0.0006
m/p-xylene	0.970	1.700	0.310	< 0.0001	6.400	0.820	0.0073
o-xylene	0.190	0.650	0.460	< 0.0001	3.300	< 0.055	0.0071
OTHER (µg/g)							
Total Petroleum Hydrocarbons	< 55	110	280	< 54	3100	< 54	< 55

Notes:

< = Less than detection limit.

NR = Not Requested





TABLE 7-7  
RI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	TS-31 7 ft TSJ3109X	TS-31 9 ft TSJ3111X	TS-33 7 ft TSJ3309F	TS-33 9 ft TSJ3311F	TS-35 7 ft TSJ3509F	TS-37 7 ft TSJ3709F	TS-37 9 ft TSJ3711F	TS-39 7 ft TSJ3909F	TS-39 9 ft TSJ3911F	TS-40 7 ft TSJ4009F
Vinyl Chloride	<2100	<2200	<21	<4.3	<2200	<4.3	<4.4	<4.0	<4.4	<4.3
t-1,2-DCE	<1100	<1100	<10	<2.2	<1100	<2.2	<2.2	<2.0	<2.2	<2.1
c-1,2-DCE	<1100	<1100	<10	<2.2	<1100	<2.2	<2.2	<2.0	<2.2	<2.1
Benzene	<1100	<1100	<10	<2.2	<1100	<2.2	<2.2	<2.0	<2.2	<2.1
Trichloroethene	<1100	<1100	<10	<2.2	<1100	<2.2	<2.2	<2.0	<2.2	<2.1
Toluene	<1100	8300	<10	7.6	<1100	<2.2	<2.2	<2.0	<2.2	<2.1
Tetrachloroethene	<1100	<1100	<10	<2.2	<1100	<2.2	<2.2	<2.0	<2.2	<2.1
Ethylbenzene	9600	15000	15	120E	4600	<2.2	<2.2	<2.0	<2.2	<2.1
m/p-xylene	29000	36000	39	150	17000	<4.3	<4.4	<4.0	<4.4	<4.3
o-xylene	11000	20000	23	21	7000	<2.2	<2.2	<2.0	<2.2	<2.1
1,1,2,2-TCA	<2100	<2200	<21	<4.3	<2200	<4.3	<4.4	<4.0	<4.4	<4.3
1,2-dichlorobenzene	<1100	<1100	<10	<2.2	<1100	<2.2	<2.2	<2.0	<2.2	<2.1
TPHC (mg/kg)	910	190	89	95	6600	<54	<56	140	95	92

Notes:  
E = concentrations exceeds upper end  
of calibration range.



TABLE 7-7  
RI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	TS-40 9 ft TSJ4011F	TS-41 7 ft TSJ4109F	TS-43 7 ft TSJ4309F	TS-43 9 ft TSJ4311F	TS-45 7 ft TSJ4509F	TS-45 9 ft TSJ4511F	TS-47 7 ft TSJ4709F	TS-47 9 ft TSJ4711F	TS-49 7 ft TSJ4909F	TS-51 7 ft TSJ5109F
Vinyl Chloride	<4.4	<23	<550	<1100	<540	<1100	<22	<540	<4.4	<4.3
t-1,2-DCE	<2.2	<11	<270	<560	<270	<560	<11	<270	<2.2	<2.2
c-1,2-DCE	<2.2	<11	<270	<560	<270	<560	<11	<270	<2.2	<2.2
Benzene	<2.2	<11	<270	<560	<270	<560	<11	<270	<2.2	<2.2
Trichloroethene	<2.2	<11	<270	<560	<270	<560	<11	<270	<2.2	<2.2
Toluene	<2.2	57	910	4600	<270	<560	<11	<270	<2.2	<2.2
Tetrachloroethene	<2.2	<11	<270	<560	<270	<560	<11	<270	<2.2	<2.2
Ethylbenzene	<2.2	47	8000	15000	4600	7400	<11	1500	<2.2	<2.2
m/p-xylene	<4.4	100	12000	39000	8800	7600	<22	1100	<4.4	<4.3
o-xylene	<2.2	<11	5500	18000	890	3000	<11	<270	<2.2	<2.2
1,1,2,2-TCA	<4.4	<23	<550	<1100	<540	<1100	<22	<540	<4.4	<4.3
1,2-dichlorobenzene	<2.2	<11	<270	<560	<270	<560	<11	<270	<2.2	<2.2
TPHC (mg/kg)	<55	100	650	510	99	310	250	200	<56	<54

Notes:  
E = concentrations exceeds upper end  
of calibration range.





TABLE 7-7  
RI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	TS-51 9 ft TSJ5111F	TS-52 7 ft TSJ5209F	TS-52 9 ft TSJ5211F	TS-53 7 ft TSJ5309F	TS-53 9 ft TSJ5311F	TS-54 7 ft TSJ5409F	TS-54 9 ft TSJ5411F	TS-55 7 ft TSJ5509F	TS-55 9 ft TSJ5511F	TS-56 7 ft TSJ5609F
Vinyl Chloride	<4.4	<520	<23	<560	<560	<2300	<590	<550	<560	<2200
t-1,2-DCE	<2.2	<260	<12	<280	<280	<1100	<290	<280	<280	<1100
c-1,2-DCE	<2.2	<260	<12	<280	<280	<1100	<290	<280	<280	<1100
Benzene	<2.2	<260	<12	<280	<280	<1100	<290	<280	<280	<1100
Trichloroethene	<2.2	<260	<12	<280	<280	<1100	<290	<280	<280	<1100
Toluene	<2.2	<260	<12	800	<280	<1100	<290	<280	<280	<1100
Tetrachloroethene	<2.2	<260	<12	<280	<280	<1100	<290	<280	<280	<1100
Ethylbenzene	<2.2	2700	<12	7000	1100	7900	420	1000	5800	14000
m/p-xylene	<4.4	5900	<23	13000	3700	16000	<590	2300	14000	38000
o-xylene	<2.2	1800	<12	8300	1200	6800	<290	<280	3400	14000
1,1,2,2-TCA	<4.4	<520	<23	<560	<560	<2300	<590	<550	<560	<2200
1,2-dichlorobenzene	<2.2	<260	<12	<280	<280	<1100	<290	<280	<280	<1100
TPHC (mg/kg)	<56	400	<290	240	330	680	74	340	810	1800

Notes:  
E = concentrations exceeds upper end  
of calibration range.





TABLE 7-7  
RI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	TS-56 9 ft TSJ5611F	TS-57 7 ft TSJ5709F	TS-57 9 ft TSJ5711F	TS-58 7 ft TSJ5809F	TS-58 9 ft TSJ5811F	TS-59 7 ft TSJ5909F	TS-59 9 ft TSJ5911F	TS-60 7 ft TSJ6009F	TS-60 9 ft TSJ6011F	TS-61 7 ft TSJ6109F
Vinyl Chloride	<23	<22	<22	<22	<22	<4.6	<4.6	<4.7	<4.4	<4.5
t-1,2-DCE	<11	<11	<11	<11	<11	<2.3	<2.3	<2.3	<2.2	<2.2
c-1,2-DCE	<11	<11	<11	<11	<11	<2.3	<2.3	<2.3	<2.2	<2.2
Benzene	<11	<11	<11	<11	35	<2.3	<2.3	<2.3	<2.2	<2.2
Trichloroethene	<11	<11	<11	<11	<11	<2.3	<2.3	<2.3	<2.2	<2.2
Toluene	53	31	<11	<11	190	<2.3	<2.3	<2.3	<2.2	<2.2
Tetrachloroethene	<11	<11	<11	<11	<11	<2.3	<2.3	<2.3	<2.2	<2.2
Ethylbenzene	220	190	31	15	2900E	<2.3	<2.3	<2.3	<2.2	<2.2
m/p-xylene	540	390	82	46	3200E	<4.6	<4.6	<4.7	<4.4	<4.5
o-xylene	320	110	23	15	1600E	<2.3	<2.3	<2.3	<2.2	<2.2
1,1,2,2-TCA	<23	<22	<22	<22	<22	<4.6	<4.6	<4.7	<4.4	<4.5
1,2-dichlorobenzene	<11	<11	<11	<11	<11	<2.3	<2.3	<2.3	<2.2	<2.2
TPHC (mg/kg)	<290	95	580	96	<280	150	<58	<59	95	96

Notes:  
E = concentrations exceeds upper end  
of calibration range.



TABLE 7-7  
RI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE (µg/g)	TS-61 9 ft TSJ6111F	TS-62 7 ft TSJ6209F	TS-63 7 ft TSJ6309F	TS-63 9 ft TSJ6311F	TS-64 7 ft TSJ6409F	TS-64 9 ft TSJ6411F	TS-65 7 ft TSJ6509F	TS-66 7 ft TSJ6609F	TS-66 9 ft TSJ6611F	TS-67 7 ft TSJ6709F
Vinyl Chloride	<4.5	<4.5	<22	<570	<4.4	<580	<4.3	<540	<22	<550
t-1,2-DCE	<2.2	<2.3	<11	<280	<2.2	<290	<2.1	<270	<11	<280
c-1,2-DCE	<2.2	<2.3	<11	<280	<2.2	<290	<2.1	<270	<11	<280
Benzene	<2.2	<2.3	<11	<280	<2.2	<290	<2.1	<270	130	<280
Trichloroethene	<2.2	<2.3	<11	<280	<2.2	<290	<2.1	<270	<11	<280
Toluene	<2.2	<2.3	790E	370	<2.2	2500	<2.1	<270	6000	380
Tetrachloroethene	<2.2	<2.3	<11	<280	<2.2	<290	<2.1	<270	<11	<280
Ethylbenzene	<2.2	<2.3	460	2200	13	5300	<2.1	310	5400E	6500
m/p-xylene	<4.5	<4.5	2900E	3200	43	12000	<4.3	900	8500E	11000
o-xylene	<2.2	<2.3	600E	1900	30	4600	<2.1	410	7000E	2700
1,1,2,2-TCA	<4.5	<4.5	<22	<570	<4.4	<580	<4.3	<540	<22	<550
1,2-dichlorobenzene	<2.2	<2.3	<11	<280	<2.2	<290	<2.1	<270	<11	<280
TPHC (mg/kg)	240	<57	94	1200	420	300	<54	420	640	570

Notes:  
E = concentrations exceeds upper end  
of calibration range.





TABLE 7-7  
RI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	TS-67 9 ft TSJ6711F	TS-68 7 ft TSJ6809F	TS-68 9 ft TSJ6811F	TS-69 7 ft TSJ6909F	TS-69 9 ft TSJ6911F	TS-70 7 ft TSJ7009F	TS-70 9 ft TSJ7011F	TS-71 7 ft TSJ7109F	TS-73 7 ft TSJ7309F	TS-73 9 ft TSJ7311F
Vinyl Chloride	<540	<22	<22	<4.3	<4.4	<4.5	<4.4	<4.5	<4.3	<4.5
t-1,2-DCE	<270	<11	<11	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2
c-1,2-DCE	<270	<11	<11	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2
Benzene	<270	<11	84	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2
Trichloroethene	<270	<11	<11	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2
Toluene	12000	57	1600	<2.2	3.3	<2.2	<2.2	<2.2	<2.2	<2.2
Tetrachloroethene	<270	<11	<11	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2
Ethylbenzene	30000E	620E	770E	<2.2	51	<2.2	<2.2	<2.2	<2.2	<2.2
m/p-xylene	56000E	1400E	5900E	<4.3	96	94	<4.4	<4.5	<4.3	<4.5
o-xylene	36000E	790E	9200E	<2.2	22	<2.2	<2.2	<2.2	<2.2	<2.2
1,1,2,2-TCA	<540	<22	<22	<4.3	<4.4	<4.5	<4.4	<4.5	<4.3	<4.5
1,2 - dichlorobenzene	<270	<11	<11	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2
TPHC (mg/kg)	920	530	280	<54	<56	<56	<55	<56	<54	<56

Notes:  
E = concentrations exceeds upper end  
of calibration range.





TABLE 7-7  
RI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	TS-74 7 ft TSJ7409F	TS-74 9 ft TSJ7411F	TS-74 9 ft TSJ7411W	TS-75 7 ft TSJ7509F	TS-75 9 ft TSJ7511F	TS-76 7 ft TSJ7609F	TS-76 9 ft TSJ7611F	TS-76 9 ft TSJ7611W	TS-77 7 ft TSJ7709F	TS-77 9 ft TSJ7711F
Vinyl Chloride	<4.4	<4.4	<4.0	<4.4	<4.4	<4.4	<4.5	<4.0	<4.5	<4.4
t-1,2-DCE	<2.2	<2.2	<2.0	<2.2	<2.2	<2.2	<2.3	<2.0	<2.3	<2.2
c-1,2-DCE	<2.2	<2.2	<2.0	<2.2	<2.2	<2.2	<2.3	<2.0	<2.3	<2.2
Benzene	<2.2	12	4.5	<2.2	<2.2	<2.2	<2.3	<2.0	<2.3	<2.2
Trichloroethene	<2.2	<2.2	<2.0	<2.2	<2.2	<2.2	<2.3	<2.0	<2.3	<2.2
Toluene	<2.2	46	<2.0	2.8	<2.2	<2.2	<2.3	<2.0	<2.3	<2.2
Tetrachloroethene	<2.2	<2.2	<2.0	<2.2	<2.2	<2.2	<2.3	<2.0	<2.3	<2.2
Ethylbenzene	6.7	77	15	15	4.9	<2.2	<2.3	<2.0	<2.3	<2.2
m/p-xylene	<4.4	180	4.4	38	13	<4.4	<4.6	<4.0	<4.5	<4.4
o-xylene	3.9	98	<2.0	24	9.6	<2.2	<2.3	<2.0	<2.3	<2.2
1,1,2,2-TCA	<4.4	<4.4	<4.0	<4.5	<4.4	<4.4	<4.6	<4.0	<4.5	<4.4
1,2-dichlorobenzene	<2.2	<2.2	<2.0	<2.2	<2.2	<2.2	<2.3	<2.0	<2.3	<2.2
TPHC (mg/kg)	<55	<55	<50	<56	<55	<56	<58	<50	<57	<56

Notes:  
B = concentrations exceeds upper end  
of calibration range.



TABLE 7-7  
RI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	TS-78 7 ft TSJ7809F	TS-78 9 ft TSJ7811F	TS-79 7 ft TSJ7909F	TS-79 9 ft TSJ7911F	TS-81 7 ft TSJ8107F	TS-82 7 ft TSJ8209F	TS-82 9 ft TSJ8211F	TS-83 7 ft TSJ8309F	TS-83 9 ft TSJ8311F	TS-84 7 ft TSJ8409F
Vinyl Chloride	<4.4	<4.4	<4.4	<4.4	<4.2	<4.4	<4.4	<4.5	<4.5	<4.4
t-1,2-DCE	<2.2	<2.2	<2.2	<2.2	<2.1	<2.2	<2.3	<2.3	2.4	<2.2
c-1,2-DCE	<2.2	<2.2	<2.2	<2.2	<2.1	<2.2	<2.3	<2.2	<2.2	<2.2
Benzene	<2.2	<2.2	<2.2	<2.2	<2.1	<2.2	<2.3	<2.2	<2.2	<2.2
Trichloroethene	<2.2	<2.2	<2.2	<2.2	<2.1	<2.2	<2.3	<2.2	<2.2	<2.2
Toluene	<2.2	<2.2	<2.2	<2.2	<2.1	<2.2	<2.3	<2.2	<2.2	<2.2
Tetrachloroethene	<2.2	<2.2	<2.2	<2.2	<2.1	<2.2	<2.3	<2.2	<2.2	<2.2
Ethylbenzene	<2.2	<2.2	<2.2	<2.2	<2.1	<2.2	<2.3	<2.2	<2.2	<2.2
m/p-xylene	<4.4	<4.4	<4.4	<4.4	<4.2	<4.4	<4.5	<4.5	<4.5	<4.4
o-xylene	<2.2	<2.2	<2.2	<2.2	<2.1	<2.2	<2.3	<2.2	<2.2	<2.2
1,1,2,2-TCA	<4.4	<4.4	<4.4	<4.4	<4.2	<4.4	<4.5	<4.5	<4.5	<4.4
1,2-dichlorobenzene	<2.2	<2.2	<2.2	<2.2	<2.1	<2.2	<2.3	<2.2	<2.2	<2.2
TPHC (mg/kg)	<55	<55	<55	<55	<52	<56	<57	<56	<56	<56

Notes:  
E = concentrations exceeds upper end  
of calibration range.





TABLE 7-7  
RI TERRAPROBE SOIL SAMPLE FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	TS-84 9 ft TSJ8411F	TS-84 9 ft TSJ8411W	TS-85 7 ft TSJ8509F	TS-85 9 ft TSJ8511F	TS-85 9 ft TSJ8511W	TS-86 7 ft TSJ8609F	TS-86 9 ft TSJ8611F	TS-86 9 ft TSJ8611W	TS-87 7 ft TSJ8709F	TS-87 9 ft TSJ8711F
Vinyl Chloride	<4.4	<4.0	<4.5	<4.5	<4.0	<4.4	<4.5	<4.0	<4.1	<4.4
t-1,2-DCE	<2.2	<2.0	<2.3	<2.3	<2.0	<2.2	<2.2	<2.0	<2.1	<2.2
c-1,2-DCE	<2.2	<2.0	<2.3	<2.3	<2.0	<2.2	<2.2	<2.0	<2.1	<2.2
Benzene	<2.2	<2.0	<2.3	<2.3	<2.0	<2.2	<2.2	<2.0	<2.1	<2.2
Trichloroethene	<2.2	<2.0	<2.3	<2.3	<2.0	<2.2	<2.2	<2.0	<2.1	<2.2
Toluene	<2.2	<2.0	<2.3	<2.3	<2.0	<2.2	<2.2	<2.0	<2.1	<2.2
Tetrachloroethene	<2.2	<2.0	<2.3	<2.3	<2.0	<2.2	<2.2	<2.0	<2.1	<2.2
Ethylbenzene	<2.2	<2.0	<2.3	<2.3	<2.0	<2.2	<2.2	<2.0	<2.1	<2.2
m/p-xylene	<4.4	<4.0	<4.5	<4.5	<4.0	<4.4	<4.5	<4.0	<4.1	<4.4
o-xylene	<2.2	<2.0	<2.3	<2.3	<2.0	<2.2	<2.2	<2.0	<2.1	<2.2
1,1,2,2-TCA	<4.4	<4.0	<4.5	<4.5	<4.0	<4.4	<4.5	<4.0	<4.1	<4.4
1,2-dichlorobenzene	<2.2	<2.0	<2.3	<2.3	<2.0	<2.2	<2.2	<2.0	<2.1	<2.2
TPHC (mg/kg)	<56	<50	<57	<57	<50	<56	<56	<50	<52	<56

Notes:  
B = concentrations exceeds upper end  
of calibration range.





TABLE 7-8  
RI SOIL BORING FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	XJB-94-02X 5 ft SBJ0405F	XJB-94-02X 7 ft SBJ0407F	XJB-94-02X 9 ft SBJ0409F	XJB-94-03X 5 ft SBJ0205F	XJB-94-03X 7 ft SBJ0207F	XJB-94-03X 9 ft SBJ0209F	XJB-94-03X 11 ft SBJ0211F	XJB-94-03X 15 ft SBJ0215F
Vinyl chloride	<4.3	<4.4	<23	<4.5	<560	<22	<1100	<4.5
t-1,2-DCE	<2.1	<2.2	<11	<2.2	<280	<11	<560	<2.2
c-1,2-DCE	<2.1	<2.2	<11	<2.2	<280	<11	<560	<2.2
Benzene	<2.1	<2.2	50	<2.2	<280	<11	590	<2.2
Trichloroethene	<2.1	<2.2	<11	<2.2	<280	<11	<560	<2.2
Toluene	<2.1	<2.2	570	<2.2	<280	<11	3800	<2.2
Tetrachloroethene	<2.1	<2.2	<11	<2.2	<280	<11	<560	<2.2
Ethylbenzene	<2.1	6.0	1500E	<2.2	2000	49	14000	<2.2
m/p - xylene	<4.3	25	1600E	<4.5	5400	170	32000	<4.5
o - xylene	<2.1	11	800E	<2.2	2400	68	19000	<2.2
1,1,2,2-TCA	<4.3	<4.4	<23	<4.5	<560	<22	<1100	<4.5
1,2 - dichlorobenzene	<2.1	<2.2	<11	<2.2	<280	<11	<560	<2.2
TPHC (mg/kg)	250	200	520	2400	460	650	1400	<56

Notes:  
E = concentration exceeds upper end of calibration range.



TABLE 7-8  
RI SOIL BORING FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	XJB-94-04X SBJ0401F 1 ft	XJB-94-04X SBJ0405F 5 ft	XJB-94-04X SBJ0410F 10 ft	XJB-94-04X SBJ0415F 15 ft	XJB-94-04X SBJ0420F 20 ft	XJB-94-05X SBJ0501F 1 ft	XJB-94-05X SBJ0503F 3 ft	XJB-94-05X SBJ0505F 5 ft
Vinyl chloride	<4.5	<4.5	<4.4	<4.3	<4.4	<4.2	<4.1	<4.1
t-1,2-DCE	<2.3	<2.2	<2.2	<2.1	<2.2	<2.1	<2.1	<2.1
c-1,2-DCE	<2.3	<2.2	<2.2	<2.1	<2.2	<2.1	<2.1	<2.1
Benzene	<2.3	<2.2	<2.2	<2.1	<2.2	<2.1	<2.1	<2.1
Trichloroethene	<2.3	<2.2	<2.2	<2.1	<2.2	<2.1	<2.1	<2.1
Toluene	<2.3	<2.2	<2.2	<2.1	<2.2	<2.1	<2.1	<2.1
Tetrachloroethene	<2.3	<2.2	<2.2	<2.1	<2.2	<2.1	<2.1	<2.1
Ethylbenzene	<4.5	<4.5	<4.4	<4.3	<4.4	<4.2	<4.1	<4.1
m/p - xylene	<2.3	<2.2	<2.2	<2.1	<2.2	<2.1	<2.1	<2.1
o - xylene	<4.5	<4.5	<4.4	<4.3	<4.4	<4.2	<4.1	<4.1
1,1,2,2-TCA	<2.3	<2.2	<2.2	<2.1	<2.2	<2.1	<2.1	<2.1
1,2 - dichlorobenzene	<2.3	<2.2	<2.2	<2.1	<2.2	<2.1	<2.1	<2.1
TPHC (mg/kg)	<57	<53	<55	<54	<55	<52	610	<52

Notes:

E = concentration exceeds upper end of calibration range.





TABLE 7-8  
RI SOIL BORING FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	XJB-94-05X 7 ft SBJ0507F	XJB-94-05X 9 ft SBJ0509F	XJB-94-05X 11 ft SBJ0511F	XJB-94-05X 13 ft SBJ0513F	XJB-94-05X 15 ft SBJ0515F	XJB-94-05X 17 ft SBJ0517F	XJB-94-06X 5 ft SBJ0605F	XJB-94-06X 10 ft SBJ0610F
Vinyl chloride	<4.2	<4.5	<22	<4.5	<4.4	<4.3	<4.2	<4.4
t-1,2-DCE	<2.1	<2.2	<11	<2.3	<2.2	<2.2	<2.1	<2.2
c-1,2-DCE	<2.1	<2.2	<11	<2.3	<2.2	<2.2	<2.1	<2.2
Benzene	<2.1	<2.2	<11	<2.3	<2.2	<2.2	<2.1	<2.2
Trichloroethene	<2.1	<2.2	<11	<2.3	<2.2	<2.2	<2.1	<2.2
Toluene	<2.1	4.6	84	<2.3	<2.2	<2.2	<2.1	12
Tetrachloroethene	<2.1	<2.2	<11	<2.3	<2.2	<2.2	<2.1	<2.2
Ethylbenzene	<2.1	21	520	<2.3	<2.2	<2.2	<2.1	58
m/p - xylene	<4.2	37	710	<4.5	<4.4	<4.3	<4.2	100
o - xylene	<2.1	24	180	<2.3	<2.2	<2.2	<2.1	41
1,1,2,2-TCA	<4.2	<4.5	<22	<4.5	<4.4	<4.3	<4.2	<4.4
1,2 - dichlorobenzene	<2.1	<2.2	<11	<2.3	<2.2	<2.2	<2.1	<2.2
TPHC (mg/kg)	<52	100	100	<57	<55	<54	2800	360

Notes:

E = concentration exceeds upper end of calibration range.





TABLE 7-8  
RI SOIL BORING FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	XJB-94-06X 12 ft SBJ0612F	XJB-94-06X 15 ft SBJ0615F	XJB-94-07X 7 ft SBJ0707F	XJB-94-07X 9 ft SBJ0709F	XJB-94-07X 11 ft SBJ0711F	XJB-94-07X 15 ft SBJ0715F	XJB-94-08X 7 ft SBJ0807F	XJB-94-08X 9 ft SBJ0809F
Vinyl chloride	<4.4	<4.4	<4.4	<4.5	<4.5	<4.4	<570	<1100
t-1,2-DCE	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<290	<560
c-1,2-DCE	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<290	<560
Benzene	3.8	9.9	<2.2	<2.2	<2.2	<2.2	340	3500
Trichloroethene	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<290	<560
Toluene	22	190E	<2.2	<2.2	<2.2	<2.2	910	26000
Tetrachloroethene	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<290	<560
Ethylbenzene	220E	700E	<2.2	<2.2	<2.2	<2.2	7700	44000E
m/p - xylene	360E	910E	<4.4	<4.5	<4.5	<4.4	22000	93000E
o - xylene	160E	680E	<2.2	<2.2	<2.2	<2.2	8500	51000
1,1,2,2-TCA	<4.4	<4.4	<4.4	<4.5	<4.5	<4.4	<570	<1100
1,2 - dichlorobenzene	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<290	<560
TPHC (mg/kg)	100	150	<55	<56	<56	<56	1600	2500

Notes:

E = concentration exceeds upper end of calibration range.



TABLE 7-8  
RI SOIL BORING FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	XJB-94-08X 11 ft SBJ0811F	XJB-94-09 7 ft SBJ0907F	XJB-94-09 9 ft SBJ0909F	XJB-94-09 11 ft SBJ0911F	XJB-94-10X 7 ft SBJ1007F	XJB-94-10X 9 ft SBJ1009F	XJB-94-10X 11 ft SBJ1011F	XJB-94-10X 15 ft SBJ1015F
Vinyl chloride	<2200	<4.5	<4.5	<4.6	<4.4	<23	<23	<4.5
t-1,2-DCE	<1100	<2.3	<2.3	<2.3	<2.2	<12	<11	<2.2
c-1,2-DCE	<1100	<2.3	<2.3	<2.3	<2.2	<12	<11	<2.2
Benzene	<1100	<2.3	<2.3	<2.3	<2.2	<12	38	<2.2
Trichloroethene	<1100	<2.3	<2.3	<2.3	<2.2	<12	<11	<2.2
Toluene	3300	<2.3	<2.3	21	7.8	<12	550	<2.2
Tetrachloroethene	<1100	<2.3	<2.3	<2.3	<2.2	<12	<11	<2.2
Ethylbenzene	8600	<2.3	<2.3	43	260E	250	1600E	6.6
m/p - xylene	24000	<4.5	<4.5	33	450E	480	2700E	20
o - xylene	11000	<2.3	<2.3	37	170E	39	1500E	4.0
1,1,2,2-TCA	<2200	<4.5	<4.5	<4.6	<4.4	<23	<23	<4.5
1,2 - dichlorobenzene	<1100	<2.3	<2.3	<2.3	<2.2	<12	<11	<2.2
TPHC (mg/kg)	3400	<57	<57	<58	200	<290	210	260

Notes:

E = concentration exceeds upper end of calibration range.





TABLE 7-8  
RI SOIL BORING FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	XJB-94-10X 20 ft SBJ1020F	XJB-94-11 7 ft SBJ1107F	XJB-94-11 9 ft SBJ1109F	XJB-94-11 11 ft SBJ1111F	XJB-94-11 15 ft SBJ1115F	XJB-94-12X 7 ft SBJ1207F	XJB-94-12X 9 ft SBJ1209F	XJB-94-12X 11 ft SBJ1211F
Vinyl chloride	<4.4	<1100	<560	<1200	<4.4	<4.4	<4.5	<4.5
t-1,2-DCE	<2.2	<550	<280	<590	<2.2	<2.2	<2.3	<2.2
c-1,2-DCE	<2.2	<550	<280	<590	<2.2	<2.2	<2.3	<2.2
Benzene	<2.2	690	820	<590	<2.2	<2.2	<2.3	<2.2
Trichloroethene	<2.2	<550	<280	<590	<2.2	<2.2	<2.3	<2.2
Toluene	<2.2	40000	26000E	<590	<2.2	<2.2	3.1	4.6
Tetrachloroethene	<2.2	<550	<280	<590	<2.2	<2.2	<2.3	<2.2
Ethylbenzene	<2.2	97000E	27000E	1800	<2.2	<2.2	<2.3	30
m/p - xylene	<4.4	180000E	60000E	6100	<4.4	<4.4	6.9	60
o - xylene	<2.2	120000E	30000E	1500	<2.2	<2.2	<2.3	37
1,1,2,2-TCA	<4.4	<1100	<560	<1200	<4.4	<4.4	<4.5	<4.5
1,2 - dichlorobenzene	<2.2	<550	<280	<590	<2.2	<2.2	<2.3	<2.2
TPHC (mg/kg)	<55	2400	460	650	<55	<55	<57	<56

Notes:  
E = concentration exceeds upper end of calibration range.





TABLE 7-8  
RI SOIL BORING FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	XJB-94-13X 7 ft SBJ1307F	XJB-94-13X 9 ft SBJ1309F	XJB-94-13X 11 ft SBJ1311F	XJB-94-13X 15 ft SBJ1315F	XJB-94-14X 7 ft SBJ1407F	XJB-94-14X 9 ft SBJ1409F	XJB-94-14X 11 ft SBJ1411F
Vinyl chloride	<4.4	<4.4	<4.5	<4.5	<4.4	<4.4	<4.4
t-1,2-DCE	<2.2	<2.2	<2.2	<2.3	<2.2	<2.2	<2.2
c-1,2-DCE	<2.2	<2.2	<2.2	<2.3	<2.2	<2.2	<2.2
Benzene	<2.2	<2.2	<2.2	<2.3	<2.2	<2.2	<2.2
Trichloroethene	<2.2	<2.2	<2.2	<2.3	<2.2	<2.2	<2.2
Toluene	<2.2	<2.2	<2.2	<2.3	<2.2	<2.2	<2.2
Tetrachloroethene	<2.2	<2.2	<2.2	<2.3	<2.2	<2.2	<2.2
Ethylbenzene	<4.4	<4.4	<4.5	<4.5	<4.4	<4.4	<4.4
m/p - xylene	<2.2	<2.2	<2.2	<2.3	<2.2	<2.2	<2.2
o - xylene	<4.4	<4.4	<4.5	<4.5	<4.4	<4.4	<4.4
1,1,2,2-TCA	<2.2	<2.2	<2.2	<2.3	<2.2	<2.2	<2.2
1,2 - dichlorobenzene	<55	<56	<56	310	1100	1400	<56
TPHC (mg/kg)							

Notes:

E = concentration exceeds upper end of calibration range.



TABLE 7-8  
RI SOIL BORING FIELD ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/g}$ )	XJB-94-14X 15 ft SBJ1415F	XJB-94-15X 7 ft SBJ1507F	XJB-94-15X 9 ft SBJ1509F	XJB-94-15X 11 ft SBJ1511F	XJB-94-15X 15 ft SBJ1515F
Vinyl chloride	<4.4	<4.6	<4.5	<4.6	<4.5
t-1,2-DCE	<2.2	<2.3	<2.3	<2.3	<2.2
c-1,2-DCE	<2.2	<2.3	<2.3	<2.3	<2.2
Benzene	<2.2	<2.3	<2.3	<2.3	<2.2
Trichloroethene	<2.2	<2.3	<2.3	<2.3	<2.2
Toluene	<2.2	<2.3	<2.3	<2.3	<2.2
Tetrachloroethene	<2.2	<2.3	<2.3	<2.3	<2.2
Ethylbenzene	<2.2	<2.3	<2.3	<2.3	<2.2
m/p - xylene	<4.4	<4.6	<4.5	<4.6	<4.5
o - xylene	<2.2	<2.3	<2.3	<2.3	<2.2
1,1,2,2-TCA	<4.4	<4.6	<4.5	<4.6	<4.5
1,2 - dichlorobenzene	<2.2	<2.3	<2.3	<2.3	<2.2
TPHC (mg/kg)	<55	<58	<57	<57	<56

Notes:

E = concentration exceeds upper end of calibration range.





TABLE 7-9  
SOIL BORING OFF-SITE LABORATORY HITS-ONLY ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

PORT DEVENS BACKGROUND CONCENTRATIONS			SI		RI									
ANALYTES	FIELD SAMPLE NO.:	DEPTH:	43J-92-01X	XJB-94-02X	XJB-94-02X	XJB-94-03X	XJB-94-03X	XJB-94-03X	XJB-94-04X	XJB-94-04X	XJB-94-04X			
			5 ft	5 ft	7 ft	11 ft	15 ft	10 ft	20 ft					
PAL METALS (µg/g)														
Aluminum	18000		NA	5520	6440	6520	4390	5780	11300					
Antimony	0.5		NA	<1.09	<1.09	3.28	<1.09	<1.09	<1.09					
Arsenic	19		NA	19	16	20	20	14	14					
Barium	54		NA	16.2	17.9	19.7	14.9	14.6	41.5					
Beryllium	0.81		NA	<.5	.723	<.5	<.5	<.5	<.5					
Cadmium	1.28		NA	<.7	<.7	<.7	<.7	<.7	<.7					
Calcium	810		NA	444	1460	984	981	684	5210					
Chromium	33		NA	16.2	14.4	20.2	10.7	17.4	24.5					
Cobalt	4.7		NA	10.8	6.49	9.27	6.37	8.09	8.81					
Copper	13.5		NA	34.8	14.2	16.9	12.9	14.4	15.5					
Iron	18000		NA	20400	15600	17800	12600	14500	18100					
Lead	48		NA	6.55	12	11	11	6.21	7.32					
Magnesium	5500		NA	3040	2770	3930	2680	3280	5930					
Manganese	380		NA	502	313	828	188	173	361					
Nickel	14.6		NA	40	30.2	36.9	21.9	30.8	31.2					
Potassium	2400		NA	691	582	847	472	441	1990					
Sodium	234		NA	378	440	421	383	353	407					
Vanadium	32.3		NA	7.89	8.28	9.1	6.46	8.31	17.7					
Zinc	43.9		NA	23.4	34.7	35.3	34.3	32.9	44.5					
PAL SEMIVOLATILE ORGANICS (µg/g)														
2-methylnaphthalene			NA	<.049	<.049	.99	<.049	<.049	<.049					
*Bis(2-ethylhexyl) Phthalate			NA	<.62	.76	1	<.62	<.62	<.62					
*Di-n-butyl Phthalate			NA	<.061	1.3	1.4	<.061	<.061	<.061					
Naphthalene			NA	<.037	<.037	.95	<.037	<.037	<.037					
Phenanthrene			NA	<.033	<.033	<.033	<.033	<.033	<.033					
Pyrene			NA	<.033	<.033	<.033	<.033	<.033	<.033					
PAL VOLATILE ORGANICS (µg/g)														
Ethylbenzene			<.0017	<.0017	<.0017	10	<.0017	<.0017	<.0017					
Toluene			<.00078	<.00078	<.00078	5	<.00078	<.00078	<.00078					
Xylenes			.022	<.0015	<.0015	40	<.0015	<.0015	<.0015					
*Acetone			<.017	<.017	<.017	<.8	<.017	<.017	<.017					
*Chloroform			<.00087	<.00087	<.00087	<.4	<.00087	<.00087	<.00087					
*Trichlorofluoromethane			<.0059	.016	<.0059	<.3	.0089	<.0059	<.0059					
OTHER (µg/g)														
Total Organic Carbon			NA	NA	NA	NA	NA	NA	NA					
Total Petroleum Hydrocarbons			1770	62.1	63.6	143	<28.5	80.2	49.4					

Notes:  
Shaded values exceed background concentrations.

< - Less than the detection limit

\* - Probable Laboratory Contaminant

1 - Source for background concentration data is RI Report for Functional Area II, Fort Devens, MA, August 1994, by Ecology and Environment, Inc. for the U.S. Army Environmental Center. The value presented for background is the maximum of the range of concentrations.

NA = not analyzed

B = analyte found in the method or QC blank as well as the sample.

D = duplicate

I = Interferences in sample make quantitation and/or identification suspect.





TABLE 7-9  
SOIL BORING OFF-SITE LABORATORY HITS-ONLY ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

FORT DEVENS BACKGROUND CONCENTRATIONS		SITE ID: DEPTH:	RI						
ANALYTES	CONCENTRATIONS	FIELD SAMPLE NO.:	XJB-94-05X 5 ft BSSJ0505	XJB-94-05X 15 ft BXXJ0515	XJB-94-06X 12 ft BXXJ0612	XJB-94-06X 15 ft BXXJ0615	XJB-94-07X 9 ft BXXJ0709	XJB-94-07X 11 ft BXXJ0711	XJB-94-07X 11 ft BDXJ0711
PAL METALS (µg/g)									
Aluminum	18000		2800	7380	6300	10900	7180	5600	4520
Antimony	0.5		<1.09	<1.09	<1.09	<1.09	<1.09	<1.09	<1.09
Arsenic	19		8.06	20	9.4	14	13.1	15	15
Barium	54		12.1	26.1	19.6	56.5	19	13.5	12.6
Beryllium	0.81		<5	<5	<5	<5	<5	<5	<5
Cadmium	1.28		<7	<7	<7	<7	<7	<7	<7
Calcium	810		321	1540	1210	2600	772	675	620
Chromium	33		6.67	16.9	15.2	44	12	12.9	12.4
Cobalt	4.7		<1.42	6.78	5.99	9.93	5.63	9.67	6.94
Copper	13.5		4.49	13.5	18.2	12.1	13.4	13.4	13.7
Iron	18000		3540	13700	12900	19000	13200	14700	12400
Lead	48		3.18	6.85	6.7	9.81	7.82	4.93	4.13
Magnesium	5500		1070	3460	3050	7430	3120	2980	2110
Manganese	380		62.8	412	372	906	274	156	370
Nickel	14.6		5.3	22.9	23.2	33.3	30	28.5	21
Potassium	2400		671	1150	733	2950	650	431	378
Sodium	234		396	389	388	499	406	415	388
Vanadium	32.3		5.14	11.4	9.08	31.4	8.13	8.27	6.25
Zinc	43.9		10.1	32.6	28.9	45.2	29.9	27.2	27.5
PAL SEMIVOLATILE ORGANICS (µg/g)									
2-methylnaphthalene			<0.49	<0.49	.093	<0.49	<0.49	<0.49	<0.49
*Bis (2-ethylhexyl) Phthalate			<62	<62	<62	<62	<62	<62	<62
*Di-n-butyl Phthalate			<0.61	<0.61	<0.61	<0.61	<0.61	<0.61	<0.61
Naphthalene			<0.37	<0.37	<0.37	<0.37	<0.37	<0.37	<0.37
Phenanthrene			<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
Pyrene			<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33
PAL VOLATILE ORGANICS (µg/g)									
Ethylbenzene			<0.017	<0.017	.011	<0.017	<0.017	<0.017	<0.017
Toluene			<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	<0.0078	<0.0078
Xylenes			<0.015	<0.015	.029	<0.015	<0.015	<0.015	<0.015
*Acetone			<0.017	<0.017	.044	<0.017	<0.017	<0.017	<0.017
*Chloroform			<0.0087	<0.0087	.0081	<0.0087	<0.0087	<0.0087	<0.0087
*Trichlorofluoromethane			<0.0059	<0.0059	<0.0059	<0.0059	.018	.0057	<0.0059
OTHER (µg/g)									
Total Organic Carbon			NA	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons			390	49.8	112	<28.2	<28.3	123	566

Notes: Shaded values exceed background concentrations.

< - Less than the detection limit

\* - Probable Laboratory Contaminant

1 - Source for background concentration data is RI Report for Functional Area II, Fort Devens, MA, August 1994, by Ecology and Environment, Inc. for the U.S. Army Environmental Center. The value presented for background is the maximum of the range of concentrations.

NA = not analyzed

B = analyte found in the method or QC blank as well as the sample.

D = duplicate

I = Interferences in sample make quantitation and/or identification suspect.



TABLE 7-9  
SOIL BORING OFF-SITE LABORATORY HITS-ONLY ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

FORT DEVENS BACKGROUND		SITE ID: DEPTH:		RI					
ANALYTES	CONCENTRATIONS	FIELD SAMPLE NO.:	XJB-94-08X 7 ft BXJ10807	XJB-94-08X 9 ft BXJ10809	XJB-94-09X 7 ft BXJ10907	XJB-94-09X 9 ft BXJ10909	XJB-94-10X 7 ft BXJ11007	XJB-94-10X 20 ft BXJ1020	XJB-94-11X 7 ft BXJ1107
PAL METALS (µg/g)									
Aluminum	18000		7220	6740	7770	6170	9500	12600	3950
Antimony	0.5		<1.09	<1.09	<1.09	<1.09	<1.09	<1.09	<1.09
Arsenic	19		9.62	15	15	15	13	12	14
Barium	54		16.9	15.3	20.7	19.5	26.8	50.6	19.5
Beryllium	0.81		<5	<5	<5	<5	<5	<5	<5
Cadmium	1.28		<7	<7	<7	<7	<7	<7	<7
Calcium	810		812	1130	383	409	566	6120	961
Chromium	33		12.9	18.4	11.4	11.3	19.9	28.7	14.6
Cobalt	4.7		6.39	6.86	5.14	6.9	9.84	9.23	8.15
Copper	13.5		17.3	14.8	12	11.7	15.5	17.5	19.7
Iron	18000		14400	15500	14400	14000	16400	20400	18000
Lead	48		9.54	10.4	8.82	4.7	9.02	6.61	19
Magnesium	5500		3160	3890	3230	2580	4060	6790	1680
Manganese	380		252	452	419	212	815	391	577
Nickel	14.6		26.6	28.1	28.4	31.2	35.1	29.9	33.2
Potassium	2400		598	624	472	549	1050	2480	561
Sodium	234		420	482	408	385	459	535	485
Vanadium	32.3		9.67	9.3	8.48	7.18	12	19.5	6.42
Zinc	43.9		33	33.1	30.1	26.3	39.2	45.3	21.7
PAL SEMIVOLATILE ORGANICS (µg/g)									
2-methylnaphthalene			1.8	.52	<.049	<.049	<.049	<.049	7
*Bis (2-ethylhexyl) Phthalate			<.62	<.62	<.62	8.1	2.8	<.62	<3
*Di-n-butyl Phthalate			<.061	<.061	<.061	<.061	<.061	<.061	<3
Naphthalene			.92	.71	<.037	<.037	<.037	<.037	10
Phenanthrene			<.033	<.033	<.033	<.033	<.033	<.033	<2
Pyrene			<.033	<.033	<.033	<.033	<.033	<.033	<2
PAL VOLATILE ORGANICS (µg/g)									
Ethylbenzene			10	20	<.0017	<.0017	.0042	<.0017	30
Toluene			.1	20	<.00078	<.00078	<.00078	<.00078	6
Xylenes			40	100	<.0015	<.0015	.0063	<.0015	90
*Acetone			<.2	<.3	<.017	<.017	<.017	<.017	<2
*Chloroform			<.09	<.2	<.00087	<.00087	<.00087	<.00087	<.09
*Trichlorofluoromethane			<.6	<.1	.017 B	.009 B	<.0059	.0094 B	<.6
OTHER (µg/g)									
Total Organic Carbon			NA	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons			291	119	<28.3	34.5	210	<28.2	1880

Shaded values exceed background concentrations.  
< - Less than the detection limit  
\* - Probable Laboratory Contaminant  
1 - Source for background concentration data is RI Report for Functional Area II, Fort Devens, MA, August 1994, by Ecology and Environment, Inc. for the U.S. Army Environmental Center. The value presented for background is the maximum of the range of concentrations.  
NA = not analyzed  
B = analyte found in the method or QC blank as well as the sample.  
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TABLE 7-9  
SOIL BORING OFF-SITE LABORATORY HITS-ONLY ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

FORT DEVENS BACKGROUND CONCENTRATIONS		SITE ID: DEPTH:	RI						
ANALYTES	CONCENTRATIONS	FIELD SAMPLE NO.:	XJB-94-11X 11 ft BXXJ1111	XJB-94-12X 7 ft BXXJ1207	XJB-94-12X 11 ft BXXJ1211	XJB-94-13X 9 ft BXXJ1309	XJB-94-13X 11 ft BXXJ1311	XJB-94-14X 11 ft BXXJ1411	XJB-94-14X 15 ft BXXJ1415
PAL METALS (µg/g)									
Aluminum	18000		8840	8020	7220	8690	6870	4790	6870
Antimony	0.5		<1.09	2.01	<1.09	2.21	<1.09	<1.09	<1.09
Arsenic	19		13	20	13	24	17	12	16
Barium	54		28.7	17.1	17	21.1	14.2	11.9	21.5
Beryllium	0.81		<.5	<.5	<.5	<.5	<.5	<.5	<.5
Cadmium	1.28		<.7	<.7	<.7	<.7	<.7	<.7	<.7
Calcium	810		1450	681	875	584	961	3920	2740
Chromium	33		17.8	36	13.7	32.3	18.8	10.9	14.3
Cobalt	4.7		7.7	7.57	7.78	8.41	8.61	6.04	6.22
Copper	13.5		14.5	169	28.7	24.5	16.5	10.8	11.7
Iron	18000		16700	16400	14800	16200	18900	11500	13300
Lead	48		9.9	86	7.43	54	8.02	5.32	4.89
Magnesium	5500		4090	4120	3850	4100	4200	2760	3820
Manganese	380		399	459	255	473	890	223	271
Nickel	14.6		29.3	27.4	17.8	30.1	33.1	22.1	22.7
Potassium	2400		1180	713	616	847	589	572	976
Sodium	234		468	392	366	439	402	402	444
Vanadium	32.3		12.4	20.6	8.82	17.1	11.8	6.9	10.1
Zinc	43.9		38.1	99	35.3	70.4	40.5	25.9	31.6
PAL SEMIVOLATILE ORGANICS (µg/g)									
2-methylnaphthalene			.89	<.5	<.049	<.2	<.049	<.049	<.049
*Bis (2-ethylhexyl) Phthalate			<.62	<.6	<.62	<.3	<.62	<.62	<.62
*Di-n-butyl Phthalate			<.061	<.6	<.061	<.3	<.061	<.061	<.061
Naphthalene			.75	<.4	<.037	<.2	<.037	<.037	<.037
Phenanthrene			<.033	.5	<.033	<.2	<.033	<.033	<.033
Pyrene			<.033	.7	<.033	<.2	<.033	<.033	<.033
PAL VOLATILE ORGANICS (µg/g)									
Ethylbenzene			8	<.0017	<.0017	<.0017	<.0017	<.0017	<.0017
Toluene			5	<.00078	<.00078	<.00078	<.00078	<.00078	<.00078
Xylenes			30	<.0015	<.0015	<.0015	<.0015	<.0015	<.0015
*Acetone			<.2	<.017	<.017	<.017	<.017	<.017	<.017
*Chloroform			<.09	<.00087	<.00087	<.00087	<.00087	<.00087	<.00087
*Trichlorofluoromethane			<.6	.0082	<.0059	.0063	.0071	.0067	<.0059
OTHER (µg/g)									
Total Organic Carbon			NA	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons			65.6	555	46.2	298	<28.3	195	<28.3

Notes:  
Shaded values exceed background concentrations.  
< - Less than the detection limit

1 - Probable Laboratory Contaminant  
1 - Source for background concentration data is RI Report for Functional Area II, Fort Devens, MA, August 1994, by Ecology and Environment, Inc. for the U.S. Army Environmental Center. The value presented for background is the maximum of the range of concentrations.

NA = not analyzed  
B = analyte found in the method or QC blank as well as the sample.

D = duplicate

I = Interferences in sample make quantitation and/or identification suspect.





TABLE 7-9  
SOIL BORING OFF-SITE LABORATORY HITS-ONLY ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

FORT DEVENS BACKGROUND CONCENTRATIONS			RI					SSI		
ANALYTES	CONCENTRATIONS	FIELD SAMPLE NO.:	XJB-94-15X 7 ft	XJB-94-15X 15 ft	XJB-94-16X 7 ft	XJB-94-16X 20 ft	XJM-93-01X 10 ft	XJM-93-02X 5 ft	XJM-93-02X 10 ft	
PAL METALS (µg/g)										
Aluminum	18000		3090	16000	10400	10900	9680	13900	5180	
Antimony	0.5		<1.09 <sup>a</sup>	2.02	<1.09	<1.09	<1.09	<1.09	<1.09	
Arsenic	19		12	23	31	14	15	28	13	
Barium	54		6.56	57.9	26.7	45	34	49	16.3	
Beryllium	0.81		<5	<5	<5	<5	<5	<5	<5	
Cadmium	1.28		<7	<7	<7	<7	<7	<7	<7	
Calcium	810		673	1860	1170	4720	1330	1120	948	
Chromium	33		9.87	32.1	43.5	24.2	18.3	55.4	19.6	
Cobalt	4.7		3.83	16.2	14.8	9.04	6.67	12	8.08	
Copper	13.5		10.4	26.6	38.6	16.6	12.3	20.6	14.2	
Iron	18000		7870	30100	26000	19600	15300	25700	16700	
Lead	48		4.3	10.9	13	6.92	6.9	11	9.8	
Magnesium	5500		1930	6610	7730	5900	3400	8220	2750	
Manganese	380		159	664	760	441	276	425	532	
Nickel	14.6		16.6	49	50.2	32.3	22.5	43	27.7	
Potassium	2400		234	2790	1980	2070	1460	2940	506	
Sodium	234		452	517	421	526	362	422	311	
Vanadium	32.3		5.96	25.3	23.1	17	13.6	31.4	7.96	
Zinc	43.9		17.2	73	46.2	44.3	37	52.3	36	
PAL SEMIVOLATILE ORGANICS (µg/g)										
2-methylnaphthalene			<.049	<.049	<.049	<.049	<.049	<.1	<.049	
*Bis (2-ethylhexyl) Phthalate			<.62	1.9	<.62	<.62	<.62	<.1	<.62	
*Di-n-butyl Phthalate			<.061	<.061	<.061	<.061	.14	.12	<.061	
Naphthalene			<.037	<.037	<.037	<.037	<.037	<.07	<.037	
Phenanthrene			<.033	<.033	<.033	<.033	<.033	<.07	<.033	
Pyrene			<.033	<.033	<.033	<.033	<.033	<.07	<.033	
PAL VOLATILE ORGANICS (µg/g)										
Ethylbenzene			<.0017	<.0017	<.0017	<.0017	<.0017	<.0017	<.0017	
Toluene			<.00078	<.00078	<.00078	<.00078	<.00078	<.00078	<.00078	
Xylenes			<.0015	<.0015	<.0015	<.0015	<.0015	<.0015	<.0015	
*Acetone			<.017	<.017	<.017	<.017	<.017	.062	<.017	
*Chloroform			<.00087	<.00087	<.00087	<.00087	<.00087	<.00087	<.00087	
*Trichlorofluoromethane			<.0059	<.0059	.0081	.01	<.0059	.0077	<.0059	
OTHER (µg/g)										
Total Organic Carbon			NA	NA	NA	NA	NA	1050	<360	
Total Petroleum Hydrocarbons			56.8	35	<21.1	<21.2	<28.5	220	<28.5	

Notes:  
Shaded values exceed background concentrations.  
< - Less than the detection limit

\* - Probable Laboratory Contaminant  
1 - Source for background concentration data is RI Report for Functional Area II, Fort Devens, MA, August 1994, by Ecology and Environment, Inc. for the U.S. Army Environmental Center. The value presented for background is the maximum of the range of concentrations.

NA = not analyzed

B = analyte found in the method or QC blank as well as the sample.

D = duplicate

I = Interferences in sample make quantitation and/or identification suspect.



TABLE 7-9  
SOIL BORING OFF-SITE LABORATORY HITS-ONLY ANALYTICAL RESULTS  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MASSACHUSETTS

FORT DEVENS BACKGROUND			SSI		RI				
ANALYTES	CONCENTRATIONS	FIELD SAMPLE NO.:	SITE ID: DEPTH:	XJM-93-02X 10 ft BDXJ0210	XJM-93-03X 15 ft BXXJ0315	XJM-94-05X 10 ft BXXJ0510	XJM-94-06X 10 ft BXXJ0610	XJM-94-08X 15 ft BXXJ0815	XJM-94-10X 15 ft BXXJ1015
PAL METALS (µg/g)									
Aluminum	18000			6060 D	9220	NA	NA	NA	NA
Antimony	0.5			<1.09 D	<1.09	NA	NA	NA	NA
Arsenic	19			15 D	17	NA	NA	NA	NA
Barium	54			15.3 D	32.4	NA	NA	NA	NA
Beryllium	0.81			<5 D	<5	NA	NA	NA	NA
Cadmium	1.28			1.1 D	<7	NA	NA	NA	NA
Calcium	810			1350 D	8940	NA	NA	NA	NA
Chromium	33			21.6 DI	19.8 I	NA	NA	NA	NA
Cobalt	4.7			7.73 D	8.68	NA	NA	NA	NA
Copper	13.5			16.8 D	13.3	NA	NA	NA	NA
Iron	18000			18300 D	17400	NA	NA	NA	NA
Lead	48			12 DI	6.5 I	NA	NA	NA	NA
Magnesium	5500			3480 D	4590	NA	NA	NA	NA
Manganese	380			494 D	322	NA	NA	NA	NA
Nickel	14.6			30 D	29.7	NA	NA	NA	NA
Potassium	2400			481 D	1410	NA	NA	NA	NA
Sodium	234			354 D	431	NA	NA	NA	NA
Vanadium	32.3			8.36 D	13.7	NA	NA	NA	NA
Zinc	43.9			38.9 D	42	NA	NA	NA	NA
PAL SEMIVOLATILE ORGANICS (µg/g)									
2-methylnaphthalene				<.049 D	<.049	NA	NA	NA	NA
*Bis (2-ethylhexyl) Phthalate				<.62 D	<.62	NA	NA	NA	NA
*Di-n-butyl Phthalate				.13 D	<.061	NA	NA	NA	NA
Naphthalene				<.037 D	<.037	NA	NA	NA	NA
Phenanthrene				<.033 D	<.033	NA	NA	NA	NA
Pyrene				<.033 D	<.033	NA	NA	NA	NA
PAL VOLATILE ORGANICS (µg/g)									
Ethylbenzene				<.0017 D	<.0017	NA	NA	NA	NA
Toluene				<.00078 D	<.00078	NA	NA	NA	NA
Xylenes				<.0015 D	<.0015	NA	NA	NA	NA
*Acetone				<.017 D	<.017	NA	NA	NA	NA
*Chloroform				<.00087 D	<.00087	NA	NA	NA	NA
*Trichlorofluoromethane				<.0059 D	<.0059	NA	NA	NA	NA
OTHER (µg/g)									
Total Organic Carbon				649 D	3370	1320	925	1910	3790
Total Petroleum Hydrocarbons				<28.8 D	<28.5	NA	NA	NA	NA

Notes: Shaded values exceed background concentrations.

< - Less than the detection limit

\* - Probable Laboratory Contaminant

1 - Source for background concentration data is RI Report for Functional Area II, Fort Devens, MA, August 1994, by Ecology and Environment, Inc. for the U.S. Army Environmental Center. The value presented for background is the maximum of the range of concentrations.

NA = not analyzed

B = analyte found in the method or QC blank as well as the sample.

D = duplicate

I = Interferences in sample make quantitation and/or identification suspect.





TABLE 7-10  
SCREENED AUGER FIELD ANALYTICAL RESULTS  
AOC 43J HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

ANALYTE ( $\mu\text{g/L}$ )	SAJ01 13 ft.	SAJ02 15 ft.	SAJ03 13 ft.	SAJ04 11 ft.	SAJ05 12 ft.	SAJ06 13 ft.	SAJ07 8 ft.	SAJ08 13 ft.	SAJ09 10 ft.	SAJ10 13 ft.
Vinyl chloride	<4.0	<200	<4.0	<100	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
t-1,2-DCE	<2.0	<100	<2.0	<50	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
c-1,2-DCE	<2.0	<100	<2.0	<50	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Benzene	3.8	280	<2.0	460	90	<2.0	<2.0	<2.0	39	19
Trichloroethene	<2.0	<100	<2.0	<50	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Toluene	<2.0	1400	<2.0	1200	<2.0	<2.0	<2.0	<2.0	<2.0	29
Tetrachloroethene	<2.0	<100	<2.0	<50	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Ethylbenzene	<2.0	2300	<2.0	1200	<2.0	<2.0	<2.0	<2.0	4.6	160E
m/p-xylene	<4.0	1800	<4.0	750	<4.0	<4.0	<4.0	<4.0	4.5	70
o-xylene	<2.0	680	<2.0	540	3.4	<2.0	<2.0	<2.0	3.1	16
1,1,2,2-TCA	<4.0	<200	<4.0	<100	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
1,2-dichlorobenzene	<2.0	<100	<2.0	<50	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0

NOTES:

E - concentration exceeds upper end of calibration range.





TABLE 7 - II  
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS  
AOC 43 J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID	Port District Background Concentration	ATCC					
		Phd Sample Number					
		2446-01	2446-02	2446-03	2446-04	2446-05	2446-06
PAL CATIONS/ANIONS (µg/L)		NA	NA	NA	NA	NA	NA
Chloride	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA
PAL METALS (µg/L)		NA	NA	NA	NA	NA	NA
Aluminum	6870	NA	NA	NA	NA	NA	NA
Arsenic	3.03	NA	NA	NA	NA	NA	NA
Barium	10.5	NA	NA	NA	NA	NA	NA
Cadmium	39.6	NA	NA	NA	NA	NA	NA
Calcium	5	NA	NA	NA	NA	NA	NA
Chromium	14700	NA	NA	NA	NA	NA	NA
Cobalt	14.7	NA	NA	NA	NA	NA	NA
Copper	25	NA	NA	NA	NA	NA	NA
Iron	8.09	NA	NA	NA	NA	NA	NA
Lead	9100	NA	NA	NA	NA	NA	NA
Magnesium	4.25	NA	NA	NA	NA	NA	NA
Manganese	3480	NA	NA	NA	NA	NA	NA
Nickel	291	NA	NA	NA	NA	NA	NA
Potassium	34.3	NA	NA	NA	NA	NA	NA
Sodium	2370	NA	NA	NA	NA	NA	NA
Vanadium	10800	NA	NA	NA	NA	NA	NA
Zinc	11	NA	NA	NA	NA	NA	NA
PAL SEMIVOLATILE ORGANICS (µg/L)		NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene	21.1	NA	NA	NA	NA	NA	NA
1,4-dichlorobenzene		NA	NA	NA	NA	NA	NA
2,4-dimethylphenol		NA	NA	NA	NA	NA	NA
2-methylnaphthalene		NA	NA	NA	NA	NA	NA
2-methylphenol / 2-creosol		NA	NA	NA	NA	NA	NA
4-methylphenol / 4-creosol		NA	NA	NA	NA	NA	NA
Bis (2-ethylhexyl) Phthalate		NA	NA	NA	NA	NA	NA
Naphthalene		NA	NA	NA	NA	NA	NA
Phenanthrene		NA	NA	NA	NA	NA	NA
PAL VOLATILE ORGANICS (µg/L)		NA	NA	NA	NA	NA	NA
1,2-dichloroethane		NA	NA	NA	NA	NA	NA
1,3-dichloropropane (cis And Trans Isomers)		NA	NA	NA	NA	NA	NA
Acetone		NA	NA	NA	NA	NA	NA
Benzene		NA	NA	NA	NA	NA	NA
Carbon Tetrachloride		NA	NA	NA	NA	NA	NA
Chloroform		NA	NA	NA	NA	NA	NA
Ethylbenzene		NA	NA	NA	NA	NA	NA
Methylene Chloride		NA	NA	NA	NA	NA	NA
Toluene		NA	NA	NA	NA	NA	NA
PAL WATER QUALITY PARAMETERS (µg/L)		NA	NA	NA	NA	NA	NA
Alkalinity		NA	NA	NA	NA	NA	NA
Nitrite, Nitrate-not Specific		NA	NA	NA	NA	NA	NA
Nitrogen By Kjeldahl Method		NA	NA	NA	NA	NA	NA
Total Dissolved Solids		NA	NA	NA	NA	NA	NA
Total Hardness		NA	NA	NA	NA	NA	NA
Total Suspended Solids		NA	NA	NA	NA	NA	NA
OTHER (µg/L)		NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons		ND	28	140	3	6770	NA





TABLE 7-11  
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS  
AOC 43 J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Sample Data Depth Field Sample Number	ROUND 3		ROUND 4		ROUND 5		ROUND 6		ROUND 3		ROUND 4	
	2446-83 10/04/93 MD-4603X1	2446-83 9/12/794 MX-4603X2	2446-83 9/12/794 MX-4603X2	2446-83 12/04/94 MX-4603X3	2446-83 12/04/94 MX-4603X3	2446-83 12/04/94 MX-4603X3	2446-83 12/04/94 MX-4603X4	2446-83 12/04/94 MX-4603X4	2446-83 10/04/93 MX-4603X1	2446-83 10/04/93 MX-4603X1	2446-83 9/12/794 MX-4603X2	2446-83 9/12/794 MX-4603X2
PAL CATIONS/ANIONS (ppb/L)												
Chloride	NA	NA	NA	31000	NA	NA	23100	NA	NA	NA	NA	NA
Phosphate	NA	NA	NA	31.3	NA	NA	2800	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	10000	NA	NA	10000	NA	NA	NA	NA	NA
PAL METALS (ppb/L)												
Aluminum	6870	141	DF	2700	141	DF	4500	141	DF	17300	91100	DF
Antimony	3.03	4.73	DF	3.03	3.03	DF	3.03	3.03	DF	3.03	3.03	DF
Asenic	10.5	60.8	DF	65.1	DF	DF	69.7	DF	DF	118	518	DF
Barium	39.6	26.2	DF	38.1	DF	DF	42.7	DF	DF	32.9	32.9	DF
Cadmium	5	4.01	DF	4.01	DF	DF	4.01	DF	DF	4.01	4.01	DF
Calcium	14700	51600	DF	53500	DF	DF	54300	DF	DF	58100	89500	DF
Chromium	14.7	6.02	DF	6.02	DF	DF	6.02	DF	DF	6.02	6.02	DF
Cobalt	2.5	2.5	DF	2.5	DF	DF	2.5	DF	DF	2.5	2.5	DF
Copper	8.09	8.09	DF	8.09	DF	DF	8.09	DF	DF	8.09	8.09	DF
Iron	9100	92600	DF	31600	DF	DF	32300	DF	DF	32300	32300	DF
Lead	4.25	2.82	DF	2.82	DF	DF	2.82	DF	DF	2.82	2.82	DF
Magnesium	3480	10400	DF	13100	DF	DF	11600	DF	DF	11600	11600	DF
Manganese	291	5520	DF	9900	DF	DF	9450	DF	DF	9450	9450	DF
Nickel	34.3	34.3	DF	34.3	DF	DF	34.3	DF	DF	34.3	34.3	DF
Potassium	2370	2600	DF	2380	DF	DF	2350	DF	DF	2350	2350	DF
Sodium	10800	53200	DF	45000	DF	DF	41700	DF	DF	41700	41700	DF
Vanadium	11	11	DF	11	DF	DF	11	DF	DF	11	11	DF
Zinc	21.1	39.4	DF	11	DF	DF	21.1	DF	DF	21.1	21.1	DF
PAL SEMI-VOLATILE ORGANICS (ppb/L)												
1,2-dichloroethane	NA	1.7	NA	1.7	NA	NA	1.7	NA	NA	2.8	3.6	NA
1,4-dichlorobenzene	NA	1.7	NA	1.7	NA	NA	1.7	NA	NA	1.7	1.7	NA
2,4-dimethylphenol	NA	5.8	NA	5.8	NA	NA	5.8	NA	NA	5.8	5.8	NA
2-methylphenol	NA	44	NA	40	NA	NA	70	NA	NA	13	22	NA
2-methylphenol / 2-cresol	NA	3.9	NA	3.9	NA	NA	3.9	NA	NA	3.9	3.9	NA
4-methylphenol / 4-cresol	NA	1.2	NA	2	NA	NA	52	NA	NA	52	52	NA
Bis (2-ethylhexyl) Phthalate	NA	6.9	NA	9.1	NA	NA	10	NA	NA	4.8	4.8	NA
Naphthalene	NA	100	NA	200	NA	NA	300	NA	NA	60	100	NA
Phenanthrene	NA	5	NA	5	NA	NA	5	NA	NA	5	5	NA
PAL VOLATILE ORGANICS (ppb/L)												
1,2-dichloroethane (Six And Time Summ)	NA	10	NA	60	NA	NA	50	NA	NA	2	20	NA
Acetone	NA	2000	NA	5000	NA	NA	2000	NA	NA	500	900	NA
Acetone	NA	300	NA	60	NA	NA	50	NA	NA	10	5	NA
Benzene	NA	10	NA	2000	NA	NA	1000	NA	NA	60	100	NA
Carbon Tetrachloride	NA	50	NA	80	NA	NA	60	NA	NA	70	80	NA
Chloroform	NA	10	NA	60	NA	NA	60	NA	NA	10	6	NA
Ethylbenzene	NA	10	NA	60	NA	NA	60	NA	NA	10	8	NA
Methylene Chloride	NA	200	NA	3000	NA	NA	2000	NA	NA	1000	1000	NA
Toluene	NA	60	NA	1000	NA	NA	300	NA	NA	60	20	NA
PAL WATER QUALITY PARAMETERS (ppb/L)												
Alkalinity	NA	NA	NA	261000	NA	NA	243000	NA	NA	NA	NA	NA
Ammonia	NA	NA	NA	10	NA	NA	762	NA	NA	NA	NA	NA
Nitrogen By Kjeldahl Method	NA	NA	NA	183	NA	NA	762	NA	NA	NA	NA	NA
Total Dissolved Solids	NA	34000	NA	34000	NA	NA	240000	NA	NA	450000	440000	NA
Total Hardness	NA	700000	NA	700000	NA	NA	2730000	NA	NA	14000000	12000000	NA
OTHER (ppb/L)												
Total Petroleum Hydrocarbons	NA	1100	NA	NA	NA	NA	NA	NA	NA	781	200	NA





TABLE 7-11  
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS  
AOC 43 J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Sample Date Depth Field Sample Number	ROUND 5		ROUND 6		ROUND 3		ROUND 4		ROUND 5		ROUND 6	
	2446-04 12/09/94 19.5 MX4664X3	2446-04 12/09/94 19.5 MX4664X3	2446-04 03/20/95 19.5 MX4664X4	2446-04 03/20/95 19.5 MX4664X4	2446-04 03/20/95 11.5 MX4664X1	2446-04 03/20/95 11.5 MX4664X1	2446-04 03/20/95 11.5 MX4664X2	2446-04 03/20/95 11.5 MX4664X2	2446-04 03/20/95 11.5 MX4664X3	2446-04 03/20/95 11.5 MX4664X3	2446-04 03/20/95 11.5 MX4664X4	2446-04 03/20/95 11.5 MX4664X4
PAL CATIONS/ANIONS (ug/L)												
Chloride	40000	NA	35000	NA	NA	NA	NA	NA	11000	NA	11000	NA
Phosphate	590	NA	2200	NA	NA	NA	NA	NA	810	NA	810	NA
Sulfate	10000	NA	10000	NA	NA	NA	NA	NA	16000	NA	16000	NA
PAL METALS (ug/L)												
Aluminum	6870	21000	3030	141	141	141	141	141	141	141	141	141
Antimony	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Arsenic	10.5	44.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1	17.1
Barium	39.6	107	20.6	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01
Cadmium	5	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01
Calcium	14700	67700	69000	69000	69000	69000	69000	69000	69000	69000	69000	69000
Chromium	14.7	35.1	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02
Cobalt	25	25	25	25	25	25	25	25	25	25	25	25
Copper	8.09	32.5	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09
Iron	9100	37790	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600
Lead	4.25	3.9	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
Magnesium	3480	24900	14800	14800	14800	14800	14800	14800	14800	14800	14800	14800
Manganese	291	4790	4260	4260	4260	4260	4260	4260	4260	4260	4260	4260
Nickel	34.3	62.6	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3
Potassium	2370	7460	2940	2940	2940	2940	2940	2940	2940	2940	2940	2940
Sodium	10800	67200	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600
Vanadium	11	27.6	11	11	11	11	11	11	11	11	11	11
Zinc	21.1	75.9	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
PAL SEMIVOLATILE ORGANICS (ug/L)												
1,2-dichlorobenzene	4.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1,4-dichlorobenzene	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
2,4-dimethylphenol	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
2-methylthiophene	29	29	29	29	29	29	29	29	29	29	29	29
2-methylthiophene / 2-cresol	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
4-methylthiophene / 4-cresol	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Bis (2-ethylhexyl) Phthalate	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Naphthalene	100	100	100	100	100	100	100	100	100	100	100	100
Phenanthrene	5	5	5	5	5	5	5	5	5	5	5	5
PAL VOLATILE ORGANICS (ug/L)												
1,3-dichlorobenzene (cis And Trans Isomers)	10	10	10	10	10	10	10	10	10	10	10	10
1,3-dichlorobenzene	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1,3-dichlorobenzene	10	10	10	10	10	10	10	10	10	10	10	10
Acetone	300	300	300	300	300	300	300	300	300	300	300	300
Benzene	70	70	70	70	70	70	70	70	70	70	70	70
Carbon Tetrachloride	10	10	10	10	10	10	10	10	10	10	10	10
Chloroform	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1,1,1-trichloroethane	50	50	50	50	50	50	50	50	50	50	50	50
1,1,2-trichloroethane	500	500	500	500	500	500	500	500	500	500	500	500
PAL WATER QUALITY PARAMETERS (ug/L)												
Alkalinity	266000	266000	266000	266000	266000	266000	266000	266000	266000	266000	266000	266000
Nitrite, Nitrate-nitrogen Specific	10	10	10	10	10	10	10	10	10	10	10	10
Nitrogen By Kjeldahl Method	590	590	590	590	590	590	590	590	590	590	590	590
Total Dissolved Solids	232000	232000	232000	232000	232000	232000	232000	232000	232000	232000	232000	232000
Total Hardness	1180000	1180000	1180000	1180000	1180000	1180000	1180000	1180000	1180000	1180000	1180000	1180000
Total Suspended Solids												
OTHER (ug/L)												
Total Petroleum Hydrocarbon	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA





TABLE 7 - 11  
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS  
AOC 43 J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID: Sample Date: Depth: Field Sample Number: Field Sample Number: Field Sample Number:	ROUND 6		ROUND 3		ROUND 4		ROUND 5		ROUND 6		ROUND 3	
	XM-93-91X 03/16/95 11.5 MXXJ0154	XM-93-91X 10/07/95 16.9 MXXJ0154	XM-93-91X 10/07/95 16.9 MXXJ0154	XM-93-91X 10/07/95 16.9 MXXJ0154	XM-93-91X 01/25/94 18.9 MXXJ0154	XM-93-91X 01/25/94 18.9 MXXJ0154	XM-93-91X 12/02/94 18.9 MXXJ0154	XM-93-91X 12/02/94 18.9 MXXJ0154	XM-93-91X 12/02/94 18.9 MXXJ0154	XM-93-91X 12/02/94 18.9 MXXJ0154	XM-93-91X 12/02/94 18.9 MXXJ0154	XM-93-91X 12/02/94 18.9 MXXJ0154
PAH CATIONS/ANIONS (ug/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAH METALS (ug/L)												
Aluminum	6870	3910	141	141	141	141	141	141	141	141	141	141
Antimony	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Arsenic	10.5	51.8	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
Barium	39.6	37.7	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
Bismuth	5	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01
Calcium	14700	34600	33600	33600	33600	33600	33600	33600	33600	33600	33600	33600
Chromium	14.7	11.7	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02
Cobalt	25	25	25	25	25	25	25	25	25	25	25	25
Copper	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09
Iron	9100	63.3	24900	24900	24900	24900	24900	24900	24900	24900	24900	24900
Lead	4.25	1.26	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Magnesium	3480	7960	7960	7960	7960	7960	7960	7960	7960	7960	7960	7960
Manganese	291	7910	7910	7910	7910	7910	7910	7910	7910	7910	7910	7910
Nickel	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3
Potassium	2370	2460	1710	1710	1710	1710	1710	1710	1710	1710	1710	1710
Sodium	11	28300	28300	28300	28300	28300	28300	28300	28300	28300	28300	28300
Zinc	21.1	11	11	11	11	11	11	11	11	11	11	11
PAH SEMI-VOLATILE ORGANICS (ug/L)												
1,2-dichlorobenzene	NA	2.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-dichlorobenzene	NA	1.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-dimethylphenol	NA	5.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-methylnaphthalene	NA	1.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-methylphenol / 2-cresol	NA	3.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3-methylphenol / 4-cresol	NA	5.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-methylphenol / 4-cresol	NA	5.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-methyl-2-naphthol	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene (Gas And Triene Isomers)	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Tetrachloride	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroform	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	NA	5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAH WATER QUALITY PARAMETERS (ug/L)												
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bismuth	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OTHER (ug/L)												
1,2-dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-methylnaphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-methylphenol / 2-cresol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3-methylphenol / 4-cresol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-methylphenol / 4-cresol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-methyl-2-naphthol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene (Gas And Triene Isomers)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Tetrachloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroform	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAH WATER QUALITY PARAMETERS (ug/L)												
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bismuth	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OTHER (ug/L)												
1,2-dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-dimethylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-methylnaphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-methylphenol / 2-cresol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3-methylphenol / 4-cresol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-methylphenol / 4-cresol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-methyl-2-naphthol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene (Gas And Triene Isomers)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Tetrachloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroform	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA



TABLE 7-11  
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS  
AOC 43 J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Site ID Sample Date Depth Field Sample Number	ROUND 4 XRM-93-43X 01/27/94 11.5 MCCJ03102	ROUND 5 XRM-93-43X 12/08/94 16.1 MCCJ03103	ROUND 6 XRM-93-43X 03/21/95 16.1 MCCJ03104	ROUND 3 XRM-93-43X 10/07/93 9.2 MCCJ04051	ROUND 4 XRM-93-43X 02/02/94 9.2 MCCJ04052	ROUND 5 XRM-93-43X 12/08/94 13.8 MCCJ04053	ROUND 6 XRM-93-43X 03/21/95 13.8 MCCJ04054
PAL CATIONS/ANIONS (ug/L)							
Chloride	NA	31000	NA	NA	NA	2120	NA
Sulfate	NA	81.5	NA	NA	NA	46.9	NA
Sulfide	NA	49000	NA	NA	NA	10000	NA
PAL METALS (ug/L)							
Aluminum	6870	5260	141	141	141	193	141
Antimony	3.03	3.03	3.03	3.03	3.03	3.03	3.03
Arsenic	10.5	7.89	8.85	36.4	36.4	3.3	3.3
Barium	39.6	39.2	25.5	74.4	74.4	25	25
Bismuth	5	4.01	4.01	4.01	4.01	4.01	4.01
Calcium	14700	59900	62400	44800	44800	12100	11800
Chromium	14.7	11.5	6.02	21.4	6.02	6.02	6.02
Cobalt	25	25	25	25	25	25	25
Copper	8.09	8.09	8.09	8.09	8.09	8.09	8.09
Iron	9100	10500	414	194	8.09	8.09	8.09
Lead	4.28	5.97	12.7	18900	3370	3370	3370
Magnesium	3480	16200	13500	10300	141	126	126
Manganese	29	3460	3390	3390	3390	3390	3390
Nickel	34.3	34.3	34.3	34.3	34.3	34.3	34.3
Potassium	2370	4680	3520	3520	4250	4250	4250
Sodium	10800	66000	66000	49100	180000	4340	4110
Vanadium	11	11	11	11	11	11	11
Zinc	21.1	33.7	21.1	21.1	117	34.5	21.1
PAL SEMI-VOLATILE ORGANICS (ug/L)							
1,2-dichlorobenzene	1.7	1.7	NA	1.7	NA	1.7	1.7
1,4-dichlorobenzene	1.7	1.7	NA	1.7	NA	1.7	1.7
2,4-dimethylphenol	5.8	5.8	NA	5.8	NA	5.8	5.8
2-methylphenol	4.5	4.5	NA	4.5	NA	4.5	4.5
2-methylphenol / 4-cresol	3.9	3.9	NA	3.9	NA	3.9	3.9
4-methylphenol / 4-cresol	3.2	3.2	NA	3.2	NA	3.2	3.2
Bis (2-ethylhexyl) Phthalate	4.9	4.9	NA	4.9	NA	4.9	4.9
Naphthalene	30	30	NA	30	NA	30	30
Phenanthrene	5	5	NA	5	NA	5	5
PAL VOLATILE ORGANICS (ug/L)							
1,2-dichloroethene (cis And Trans Isomers)	2	2	NA	2	NA	2	2
1,2-dichloroethane	40	40	NA	40	NA	40	40
Acetone	100	100	NA	100	NA	100	100
Benzene	3	3	NA	3	NA	3	3
Carbon Tetrachloride	2	2	NA	2	NA	2	2
Chloroform	100	100	NA	100	NA	100	100
Ethylbenzene	10	10	NA	10	NA	10	10
Methylene Chloride	100	100	NA	100	NA	100	100
Toluene	100	100	NA	100	NA	100	100
PAL WATER QUALITY PARAMETERS (ug/L)							
Alkalinity	NA	255000	NA	NA	NA	NA	NA
Nitrite, Nitrate-Specific	NA	10	NA	NA	NA	NA	NA
Nitrogen By Kjeldahl Method	NA	248	NA	NA	NA	NA	NA
Total Dissolved Solids	430000	208000	NA	NA	NA	NA	NA
Total Hardness	NA	472000	NA	NA	NA	NA	NA
Total Suspended Solids	340000	472000	NA	NA	NA	NA	NA
OTHER (ug/L)							
Total Petroleum Hydrocarbons	210	NA	NA	3350	NA	NA	NA





TABLE 7-11  
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS  
AOC 43 J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

[illegible]





TABLE 7 - 11  
GROUNDWATER OFF-SITE LABORATORY ANALYTICAL RESULTS  
AOC 43 - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
PORT DEVENS, MA

Skr. ID: Sample Date: Depth: Field Sample Number	ROUND 6		ROUND 5		ROUND 6		ROUND 5		ROUND 6		ROUND 5		ROUND 6		ROUND 5		ROUND 6	
	XM-94-47X 03/20/95 13.3 MCCJ07X4	XM-94-47X 03/20/95 13.3 MCCJ07X4	XM-94-48X 11/26/94 17.5 MCCJ08X3	XM-94-48X 11/26/94 17.5 MCCJ08X3	XM-94-48X 03/19/95 17.5 MCCJ08X4	XM-94-48X 03/19/95 17.5 MCCJ08X4	XM-94-49X 12/01/94 19 MCCJ09X3	XM-94-49X 12/01/94 19 MCCJ09X3	XM-94-49X 03/21/95 19 MCCJ09X4	XM-94-49X 03/21/95 19 MCCJ09X4	XM-94-10X 12/01/94 18 MCCJ10X3	XM-94-10X 12/01/94 18 MCCJ10X3	XM-94-10X 03/21/95 18 MCCJ10X4	XM-94-10X 03/21/95 18 MCCJ10X4	XM-94-10X 03/21/95 18 MCCJ10X4	XM-94-10X 03/21/95 18 MCCJ10X4	XM-94-10X 03/21/95 18 MCCJ10X4	
PAL CATIONS/ANIONS (µg/L)																		
Chloride			NA	NA	8890	NA	337	34.2	NA	NA	5490	NA	5050	NA	NA	NA	NA	
Phosphate			NA	NA	34.2	NA	25.3	NA	NA	25.9	NA	304	NA	16000	NA	NA	NA	
Sulfate			NA	NA	10000	NA	10000	NA	NA	12000	NA	16000	NA	NA	NA	NA	NA	
PAL METALS (µg/L)																		
Aluminum	6870	141	141	287	171	141	2840	141	141	141	141	141	332	141	141	141	141	
Antimony	3.03	3.03	4.91	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	
Arsenic	10.5	2.54	2.54	2.77	2.54	2.54	3.94	2.54	2.54	2.54	2.54	2.54	5.65	2.54	2.54	2.54	3.73	
Barium	39.6	5	5	25.9	5	5	31.9	11.6	11.6	9.63	9.35	9.35	15.9	9.63	9.35	13.7	13.7	
Bismuth	5	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	
Calcium	14700	10800	10800	48100	7550	9240	46900	60200	60200	43000	38600	38600	43000	38600	38600	43000	43000	
Chromium	14.7	6.02	6.02	6.02	6.02	6.02	10.4	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.02	
Cobalt	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	
Copper	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	
Lead	9100	38.8	38.8	429	228	38.8	7730	38.8	38.8	38.8	38.8	38.8	464	38.8	38.8	38.8	38.8	
Iron	425	1.26	1.26	1.26	1.26	1.26	3.47	1.26	1.26	1.26	1.26	1.26	14.4	1.26	1.26	1.26	1.26	
Magnesium	3480	2240	13900	13900	1110	1490	3330	2750	16600	11300	22500	22500	23700	22500	22500	22500	22500	
Manganese	291	6.81	776	776	27.2	34.3	34.3	34.3	34.3	34.3	277	277	34.3	34.3	34.3	34.3	34.3	
Nickel	34.3	375	375	8740	599	375	2890	1660	577	537	5770	5770	3570	5770	5770	3570	3670	
Potassium	2370	13900	11900	12800	11	11	6730	7360	6300	5790	11400	10200	3370	5180	5180	3370	3670	
Sodium	10800	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	
Vanadium	11	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	
Zinc	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	
PAL SEMI-VOLATILE ORGANICS (µg/L)																		
1,2-dichlorobenzene		NA	NA	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	
1,4-dichlorobenzene		NA	NA	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	
2,4-dimethylphenol		NA	NA	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	
2-methylphenol / 2-cresol		NA	NA	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	
4-methylphenol / 4-cresol		NA	NA	41	41	41	6.2	4.8	4.8	4.8	12	12	34.3	5180	5180	34.3	3670	
Bis (2-ethylhexyl) Phthalate		NA	NA	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
Naphthalene		NA	NA	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
Phenanthrene		NA	NA	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
PAL VOLATILE ORGANICS (µg/L)																		
1,2-dichloroethylenes (cis And Trans Isomers)		NA	NA	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
1,2-dichloroethane		NA	NA	84	84	84	89	84	84	84	84	84	84	84	84	84	84	
Acetone		NA	NA	13	13	13	13	13	13	13	13	13	13	13	13	13	13	
Benzene		NA	NA	56	56	56	20	56	56	56	56	56	56	56	56	56	56	
Carbon Tetrachloride		NA	NA	58	58	58	58	58	58	58	58	58	58	58	58	58	58	
Chloroform		NA	NA	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
Ethylbenzene		NA	NA	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	
Methylene Chloride		NA	NA	73	73	73	42	73	73	73	73	73	73	73	73	73	73	
Toluene		NA	NA	194000	34000	34000	182000	182000	182000	182000	182000	182000	182000	182000	182000	182000	182000	
PAL WATER QUALITY PARAMETERS (µg/L)																		
Alkalinity		NA	NA	183	183	183	219	183	183	183	183	183	183	183	183	183	183	
Nitrite, Nitrate-nitrogen Specific		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Nitrogen By Kjeldahl Method		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Total Dissolved Solids		NA	NA	186000	24400	24400	676000	676000	676000	676000	676000	676000	676000	676000	676000	676000	676000	
Total Hardness		NA	NA	29000	28000	28000	676000	676000	676000	676000	676000	676000	676000	676000	676000	676000	676000	
Total Suspended Solids		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
OTHER (µg/L)																		
Total Petroleum Hydrocarbons		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

Notes:  
F = Filtered  
D = Duplicate  
NA = Not Analyzed  
PAL = Project Analyte List  
\* = On-site laboratory contaminant



## 8.0 CONTAMINANT FATE AND TRANSPORT

This subsection discusses the migration potential and probable environmental fate of general contaminant groups identified at AOC 43J. Compounds and analytes detected include VOCs, SVOCs, inorganics, and TPHC. The observed distribution of these contaminants in different environmental media (soil, sediment, and groundwater) is the result of their release pattern and of their physical and chemical properties. For organic chemicals, these properties include specific gravity, solubility, volatility, and organic carbon partition coefficient ( $K_{oc}$ ). For inorganic constituents, the physical and chemical properties include oxidation state of the analyte, pH, and specific solute species. Site-specific conditions governing fate and transport (e.g., persistence and migration) of analytes include contaminant concentration, topography, meteorological conditions, and in the case of groundwater, hydrogeology.

### 8.1 COMPOUND PROPERTIES AND TRANSPORT PROCESSES

The primary contaminants detected in soil at AOC 43J are fuel-related VOCs, SVOCs, and TPHC. In addition, some VOCs and SVOCs may have been introduced as laboratory contamination.

The persistence of compounds in soil is determined by chemical properties, source configurations and releases, geochemical and biochemical reactions, and soil and meteorological conditions. Factors and processes that control the persistence of chemicals in water-bearing units, in addition to the aforementioned factors, are water-bearing unit characteristics, advection, and hydrodynamic dispersion. Compounds may exist in the surface and subsurface in gaseous, aqueous, or solid phases. The fate of these compounds is controlled by a combination of all of these factors.

The following subsections discuss general physical and chemical properties, and how these properties affect transport and general attenuation processes.

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### 8.1.1 Physical and Chemical Properties Significant to Fate and Transport

This subsection discusses the physical and chemical properties that affect the fate and transport of contaminants in the environment. Physical and chemical properties of organic contaminants of concern detected at AOC 43J are presented in Table 8-1. Table 8-2 summarizes the relative mobilities of selected inorganic elements in different chemical environments.

Most physical and chemical properties of TCL analytes are described in "Basics of Pump-and-Treat Groundwater Remediation Technology" (USEPA, 1990) including specific gravities,  $K_{oc}$ , relative solubility, and relative volatility. This reference document does not include inorganics, because analyses conducted measure the total amount of a particular constituent in the sample rather than the actual chemical form or metal oxidation state. The distribution of specific solute species, pH, and oxidation are important factors in establishing the total solubility or mobility of a given inorganic element.

Specific gravity is the ratio of the mass of a given volume of a liquid substance to the mass of an equal volume of water. Liquids with specific gravities greater than 1 are termed "heavier" than water.

Solubility measures the partitioning between the aqueous phase and solid form of a chemical, and the tendency of a material to dissolve in water. Substances with lower solubilities are more likely to remain in a separate phase when in contact with water; substances with higher solubilities will dissolve into, and move with, water.

Volatility measures the tendency of a chemical to partition into the gaseous phase. Volatility can be predicted by an analyte's vapor pressure and Henry's Law Constant value (H). Volatility of a compound increases with increasing vapor pressure. Compounds with H values less than  $1.0 \times 10^{-5}$  have a low degree of volatility, and those with H values below  $3.0 \times 10^{-7}$  are considered non-volatile. H values between  $1.0 \times 10^{-5}$  and  $1.0 \times 10^{-3}$  (e.g., anthracene, naphthalene, PCBs) are moderately volatile, while those with values exceeding  $1.0 \times 10^{-3}$  (e.g., VOCs) are considered highly volatile.

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$K_{oc}$  measures the extent that an organic chemical partitions between a solid phase and a liquid phase, and is used to predict to what extent a chemical could be adsorbed to soil organic carbon. Chemicals with a  $K_{oc}$  greater than 10,000 will adsorb strongly to soil organic carbon. Chemicals with a  $K_{oc}$  ranging from 1,000 to 10,000 will moderately adsorb, and move slowly in the soil profile. Chemicals with a  $K_{oc}$  of less than 1,000 weakly adsorb to soil organic carbon and tend to be more mobile. Examples of weakly adsorbed compounds include many VOCs such as benzene and xylene.

### 8.1.2 General Transport and Attenuation Processes

Migration and persistence are controlled by various transport and attenuation processes. Processes that tend to disperse contaminants include surface water and groundwater movement (which includes the movement of dissolved and suspended contaminants), facilitated transport, leaching by dissolution or desorption, and surface erosion.

The solubility of a compound in water is considered to be the most important transport factor, because it determines the maximum concentration dissolved in water. Knowledge of the solubility of a chemical provides considerable insight into the fate and transport of that chemical. In general, highly soluble compounds are less likely to partition into soil or sediment, or to volatilize from water, and are more likely to biodegrade (Montgomery, 1991).

Dissolved phase transport can occur via two processes: advection or dispersion. Advection involves transport with flowing groundwater and migrating with the mean velocity of the solvent (groundwater plus dissolved compounds). When compounds move through the ground by advection, they are subject to spreading within the ground, which allows compounds with little or no affinity for soils to migrate faster than the groundwater velocity. This spreading is the result of a process known as dispersion. Hydrodynamic dispersion has two components: molecular diffusion and mechanical dispersion (USEPA, 1989a). Diffusion is the process by which ionic or molecular constituents move under the influence of concentration gradients. Mechanical dispersion occurs as the groundwater flows through the media, and compounds spread out through the tortuous pathways of the soil matrix, and mixes with clean water. The result is a dilution of the compound by a process known as dispersion (Fetter, 1988). At very low

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groundwater velocities, diffusion is the dominant process; at higher velocities, dispersion is the dominant process. Dispersivity is dependent on vertical and horizontal permeability variations, increasing with the degree of heterogeneity and anisotropy, and is dependent on whether flow is principally through porous media or nonporous media (e.g., fractured bedrock) (Walton, 1988).

The rate a compound migrates can be influenced by facilitated transport, which is the combined effects of physical, chemical, and/or biological phenomena that act to increase mobility. Examples of facilitated transport include particle transport, cosolvation, and phase shifting (Keely, 1989).

Particle transport involves the movement of small, solid-phase particles (such as inorganic and organic colloids), macromolecules, or emulsions to which compounds have adhered by sorption, ion exchange, or other means. High molecular weight organic compounds such as polynuclear aromatic hydrocarbons (PAHs), pesticides, and heavy metals, have a high affinity for mobile subsurface particles, and this affinity increases their mobility (Huling, 1989). Small particles, especially mobile organic carbon phase particles such as biocolloids and macromolecules (e.g., humic substances) are transported in the aqueous phase and may act as mobile sorbents.

Cosolvation is the process by which the solubility and mobility of one compound is increased by the presence of another (Keely, 1989). Naturally occurring organic compounds (e.g., humic acids) can undergo complexation reactions with metals and pesticides. Complexation reactions can increase the solubility of metals (including iron, aluminum, copper, nickel, and lead) and pesticides (e.g., DDT). In a cosolvent system, as the fraction of a water-miscible cosolvent increases, the solubilities of the metals or pesticides increase. However, the cosolvent concentration normally needs to be high to ensure a substantial increase in solute velocity. Therefore, cosolvation is important primarily near sources of groundwater impact (USEPA, 1989a). High concentrations of water-miscible phases (e.g., ketones) were not detected at AOC 43J.

Chemical phase shifts involve changes in pH and/or the redox potential of the groundwater. These shifts can increase solubilities and mobilities by ionizing neutral organics, solubilizing precipitated metals, forming complexes, or limiting biological activity (Keely, 1989). These processes are particularly important in

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determining the mobility of heavy metals. Inorganics and heavy metals are not compounds of concern at AOC 43J.

Processes that tend to attenuate migration of impacted groundwater include retardation resulting from sorption, volatilization, degradation, and precipitation. The sorption properties of individual solutes are dependent on soil and groundwater characteristics. In general, the relative amount of sorption by soil or sediment materials that do not contain organic matter is as follows: clay > silt > sand > gravel (Walton, 1988). The till beneath AOC 43J is a sandy silt. Sorption would be expected to exert a significant influence in retarding the migration of fuel-related VOCs and SVOCs in the till. Sorption would be expected to be less significant in the underlying bedrock.

The tendency of organic chemicals to be sorbed is also dependent on the organic content of the soil and the degree of hydrophobicity (lack of affinity for water) of the solute. The rate of travel for each chemical depends on the groundwater seepage velocity and the degree of sorption. If an organic chemical is extensively adsorbed by particles, it will be rendered relatively immobile. The rates and degree of volatilization, photolysis, hydrolysis, and biodegradation are directly dependent on the extent of adsorption (Montgomery, 1991). The vadose zone typically contains greater amounts of organic material and metal oxides (which may also act as sorbents) than the saturated zone, which may make the rate of movement in the vadose zone substantially less than that in the saturated zone (USEPA, 1989a).

The soil/sediment partition or sorption coefficient ( $K_{oc}$ ) is defined as the ratio of adsorbed chemical per unit weight of organic carbon to the aqueous solute concentration. The coefficient indicates the tendency of a compound to adsorb to organic carbon (degree of retardation) and, therefore, provides a means for estimation of the relative mobility of solutes (Montgomery, 1991). Mobility is a function of the relative rate of transport of a chemical versus the rate of groundwater flow. Chemicals that have relatively low mobilities (i.e., high retardation or sorption) move slowly compared to the velocity of the groundwater. Chemicals that have relatively high mobilities (i.e., low retardation or sorption) move at a rate closer to groundwater velocity. VOCs detected at AOC 43J have relatively high mobility potential, while SVOCs have moderate to high mobility potential (see Table 8-1).

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Volatilization is the transport of a compound from the liquid to the vapor phase and, ultimately, into the atmosphere. Volatilization rates are affected by soil properties, vapor pressure, temperature, and sorption. VOCs partition between the aqueous and gaseous phase in unsaturated soils. This process will occur most readily for compounds with a high vapor pressure and a high  $H$ . These compounds tend to partition off into the gas phase and occupy the available soil pore space. In addition, VOCs in the saturated zone or in surface water will partition to the gaseous phase, particularly those with lower solubility (e.g., xylenes). VOCs with greater aqueous solubility tend to remain in solution.

Volatilization is an important process in shallow soils and surface water. In recharge areas composed of sandy or gravelly soil, volatilization may be an important process, especially for compounds with moderate to high volatility (Montgomery, 1991). The effectiveness of volatilization normally decreases with depth in the soil column.

Chemicals released to the environment are susceptible to several degradation pathways, including chemical degradation (e.g., oxidation and reduction), photolysis or photochemical degradation, and biodegradation. Compounds formed by these processes may be more or less toxic and/or more or less mobile than the parent compound.

Oxidation typically involves the loss of electrons during a chemical reaction. In general, substituted aromatic compounds such as ethylbenzene and naphthalene can be oxidized. Oxidation rates for aromatic compounds are typically an order of magnitude faster than for chlorinated aliphatic compounds (e.g., 1,2-dichloroethane). Overall, abiotic (without biological life) oxidation of organic compounds in groundwater systems is extremely limited.

Photochemical breakdown processes involve structural changes in a molecule induced by radiation in the ultraviolet-visible light range. This process is unlikely to occur at AOC 43J due to contamination being confined to the subsurface environment.

Biodegradation may be defined as the breakdown of organic compounds by microorganisms through metabolic processes. Variables affecting the rate of biodegradation include:

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- Number of microorganisms (most are within 14 centimeters of the ground surface)
- Chemical properties, concentrations, and distribution
- Presence of food and nutrients
- Temperature
- pH
- Moisture and oxygen content

The rate of biodegradation tends to be higher for low molecular weight compounds. Naturally occurring soil and aquatic microorganisms capable of degrading aromatic hydrocarbons (e.g., benzene, toluene, ethylbenzene, and xylene) have been studied, and a relationship between dissolved oxygen (DO) and biodegradation has been documented (Jamison, et al., 1975; and Bailey, et al., 1973). As the aromatic hydrocarbons are mobilized by dissolution from soil or sediment, they are likely to be rapidly degraded as long as microorganisms and DO are available.

## **8.2 FATE AND TRANSPORT OF CONTAMINANTS DETECTED AT AOC 43J**

This subsection discusses the potential fate and transport of contaminants, by chemical class, detected at AOC 43J.

**VOCs.** Soil samples collected at or below the water table at AOC 43J contained the fuel-related VOCs toluene, ethylbenzene, and xylene (see Table 7-7). Fuel-related VOC TICs such as heptane and octane were also present in the soil samples (see Table 7-1). The VOCs benzene, toluene, ethylbenzene, and xylene are the primary VOCs detected in groundwater samples from AOC 43J (see Table 7-10). 1,2-dichloroethane was detected in one monitoring well (XJM-94-06X) at a concentration of 23  $\mu\text{g/L}$ . Fuel-related VOC TICs tentatively identified in groundwater include butane, isobutane, 2-methyl-1-butene,

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2-methyl-2-butene, cyclohexane, isopentane, pentane, methylocyclopentane, and 3-methylpentane (see Table 7-10).

VOCs detected at AOC 43J can be classified as aromatic hydrocarbons (e.g., BTEX) and halogenated hydrocarbons (e.g., 1,2-dichloroethane). Processes and forces that will control the fate of these VOCs include volatilization, advection/dispersion, and biodegradation.

Gravity drainage of VOCs from soil was an important transport mechanism at AOC 43J. Percolation of free-phase fuel and waste oils from leaking USTs and/or associated subsurface piping through soils was likely the initial transport mechanism for VOCs to groundwater. Factors affecting VOC percolation to groundwater are density and volatility. Compounds with higher density and low volatility are most likely to be transported to groundwater.

Dissolution of VOCs from unsaturated zone soil via infiltrating precipitation is not likely to be a dominant transport mechanism at AOC 43J due to the extensive asphalt cover of the parking lot.

Volatilization is believed to be the most significant transport mechanism for VOCs in the unsaturated soils at AOC 43J. The fuel-related VOCs at AOC 43J are likely partitioning between the aqueous and gaseous phases in the source area unsaturated soils beneath the asphalt cap. This process occurs most readily for compounds with a high vapor pressure and a high  $H$  (e.g., benzene and toluene). In addition, VOCs in the saturated zone will partition to the gaseous phase, particularly those with lower solubility (e.g., toluene, xylene, and ethylbenzene). As groundwater transports the fuel-related VOCs away from the source areas, the VOCs with lower solubility will partition to some extent into the gas phase and occupy the available soil pore space above the water table in the unsaturated zone. Headspace readings from unsaturated zone soils up to 150 feet from the source area confirm this partitioning. VOCs with greater aqueous solubility tend to partition more strongly to the aqueous phase (e.g., benzene).

Dissolved phase transport of VOCs in groundwater is also a significant transport mechanism at AOC 43J. Factors affecting partitioning of VOCs from soil to groundwater include solubility and  $K_{oc}$ . VOCs with high solubilities and low  $K_{oc}$ s, such as benzene, will partition to groundwater from the saturated zone soils.

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Results of saturated zone soil samples and groundwater samples indicate this to be the case, as benzene was detected in groundwater, but not in soil. Toluene, ethylbenzene, and xylene were detected in saturated zone soils and groundwater, which is probably a result of their moderate  $K_{oc}$ s and solubilities (see Table 8-1). Processes that tend to attenuate migration of impacted groundwater at AOC 43J include retardation resulting from sorption, volatilization, and degradation.

Biodegradation reactions act to reduce the total mass of VOCs. Naturally occurring soil and aquatic microorganisms capable of degrading aromatic hydrocarbons have been studied, and a relationship between DO and biodegradation has been documented (Jamison, et al., 1975; and Bailey, et al., 1973). As the aromatic hydrocarbons are mobilized by dissolution from the soil or sediment, they are likely to be rapidly degraded as long as DO and sufficient microorganisms are available.

Fuel-related VOC contaminants at AOC 43J are expected to be reduced through volatilization, biodegradation, and/or dilution and dispersion.

**SVOCs.** Soil samples collected at or below the water table at AOC 43J contained the fuel-related SVOCs 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene (see Table 7-9). Fuel-related SVOC TICs such as heavyweight alkanes pentadecane, hendecane, and pentacosane were also present in the soil samples (see Table 7-1). 1,2-dichlorobenzene, 2-methylnaphthalene, naphthalene, phenanthrene, pyrene, o-cresol, and p-cresol are the primary SVOCs detected in groundwater samples from AOC 43J. 1,2-dichlorobenzene was detected in one monitoring well (2446-04) at a concentration of 4.8  $\mu\text{g/L}$ . Fuel-related SVOC TICs tentatively identified in groundwater include 1,3-diethylbenzene; 1-ethyl-3-methylbenzene; trimethylbenzenes; 1,2,3,4-tetramethylbenzene; propylbenzene; 3-methylcyclohexene; cumene; isodurene; indan; hexadecanoic acid butyl ester; nonadecane; and cyclopentanone (see Table 7-1).

SVOCs detected at AOC 43J can be classified as monocyclic aromatic hydrocarbons (e.g., o-cresol, and p-cresol) and PAHs (e.g., 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene). Processes that will control the fate of these SVOCs include volatilization, sorption, advection/dispersion, and biodegradation.

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Gravity drainage of SVOCs from soil was an important transport mechanism at AOC 43J. Percolation of free-phase fuel and waste oils from leaking USTs and/or associated subsurface piping through soils was likely the initial transport mechanism for SVOCs to groundwater. Factors affecting SVOC percolation to groundwater are density and volatility. Compounds with higher density and low volatility are most likely to be transported to groundwater.

Dissolution of SVOCs from unsaturated zone soil via infiltrating precipitation is not likely to be a dominant transport mechanism at AOC 43J due to the extensive asphalt cover of the parking lot.

Volatilization is a minor transport mechanism for SVOCs in the soils and groundwater at AOC 43J. The fuel-related SVOCs at AOC 43J, such as naphthalene and phenanthrene, are considered moderately volatile, and therefore volatilization is not as significant a transport mechanism as it is for VOCs.

Dissolved phase transport of SVOCs in groundwater is a significant transport mechanism at AOC 43J. Factors affecting partitioning of SVOCs from soil to groundwater include solubility and  $K_{oc}$ . SVOCs are generally regarded as immobile because of strong adsorption to the organic carbon fraction of soil predicted through higher  $K_{oc}$ s and low solubilities (Tinsley, 1979; Kenaga and Goring, 1978). SVOCs with moderate solubilities and moderate to high  $K_{oc}$ s, such as pyrene and 2-methylnaphthalene, will partition slightly to groundwater from the saturated zone soils (see Table 8-1). Results of saturated zone soil samples and groundwater samples indicate this to be the case, as the SVOCs were detected at much higher concentrations in soil than in groundwater. Processes that tend to attenuate migration of impacted groundwater at AOC 43J include retardation resulting from sorption, volatilization, and degradation.

Biodegradation reactions act to reduce the total mass of lower molecular weight PAHs (e.g., naphthalene). Naturally occurring soil and aquatic microorganisms capable of degrading aromatic hydrocarbons have been studied, and a relationship between DO and biodegradation has been documented (Jamison, et al., 1975; and Bailey, et al., 1973). As the aromatic hydrocarbons are mobilized from the soil by groundwater movement, they are likely to be degraded as long as DO and sufficient microorganisms are available.

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The fate of fuel-related SVOC contaminants at AOC 43J is expected to be reduction through volatilization, biodegradation, and/or dilution and dispersion. The SVOCs would be expected to eventually partition out of the aqueous phase to the soil phase and remain present in the soils. The slow rate of migration (due to partitioning to soil) for the PAHs allows for significant degradation, even if degradation rates are small, before they can travel significant distances. The fuel-related PAHs also tend to be more persistent with increasing molecular weight.

**Inorganics.** Inorganics detected at AOC 43J include metals (aluminum and lead), transition metals (iron, manganese, vanadium, chromium, cobalt, cadmium, mercury, nickel, silver, zinc, and copper), alkaline earth metals (calcium, magnesium, and barium), alkali metals (sodium and potassium), and nonmetallic elements (arsenic). It should be noted that the detection of these inorganics could not be correlated with the presence of fuel-related organic compounds (see Section 7.0 of this report). Discussion of the fate and transport of inorganics, presented below, is therefore limited.

The mobility of inorganics in soil-water systems is strongly affected by compound solubility, pH, soil cation exchange capacity, soil type, oxidation-reduction potential, adsorption processes, major ion concentrations, and salinity. The distribution of inorganics would most likely be controlled by adsorption processes. Once adsorbed to soil, the inorganics may migrate with the soil by mechanical transport of particles. The migration of dissolved inorganics is dependent upon their individual adsorption characteristics (Oak Ridge National Laboratories, 1989). Mobilities of inorganic elements relative to the redox state of the environment are presented in Table 8-2. The concentrations of inorganics detected at AOC 43J appears to be a result of suspended soil particle in the groundwater samples.

### 8.3 SITE CONCEPTUAL MODEL

The site conceptual model is designed to present a simplified model encompassing the essential features of AOC 43J. Figure 8-1 presents a site conceptual model flow chart showing the potential source and transport mechanisms for the contaminants detected at AOC 43J. The model reflects the current understanding

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of the site with respect to sources of contamination, the distribution of contamination, and the potential migration pathways.

Based on the results of the previous investigations the primary site-related contaminants at AOC 43J are fuel-related contaminants in soil and groundwater. Fuel-related VOCs and TPHC were detected in the subsurface soils during each investigation and UST removal. TPHC concentrations detected in the soil samples collected during each investigation, indicated that TPHC concentrations were above the MCP S-2 soil guideline in all but one location, and individual VOCs were below the guidelines in each soil sample. Benzene, ethylbenzene and toluene were detected in groundwater samples at concentrations above the federal MCL. TPHC was also detected above the MCP GW-1 groundwater guideline. Several inorganics were also detected above their human health risk-based guidelines in the unfiltered samples collected during each round of groundwater sampling. The inorganic results for the filtered groundwater samples collected during Rounds Three through Six were either slightly above or below human health action levels, indicating that the inorganic concentrations in the unfiltered samples were a result of elevated TSS, and not due to site-related contaminants. Due to the hydrogeologic and geologic conditions at AOC 43J, it appears that the site-related contaminants have impacted the soil and groundwater quality below the former USTs and at the top of the water table downgradient of the former USTs.

The primary release mechanism appears to be leaks from the former USTs and the associated piping into the soil and bedrock below the former USTs, as well as, downgradient (southeast) of the former USTs.

A potential secondary source of groundwater contamination is the contaminated soil and bedrock below the former historic gas station and waste oil USTs, and the soil at the water table downgradient of the former USTs.

The secondary release mechanism appears to be contaminant percolation through the subsurface soil and/or bedrock and into the water table in the bedrock and soil below the site. Also, if the contaminated soil was excavated there could be release of contaminants into the air in the form of dust.

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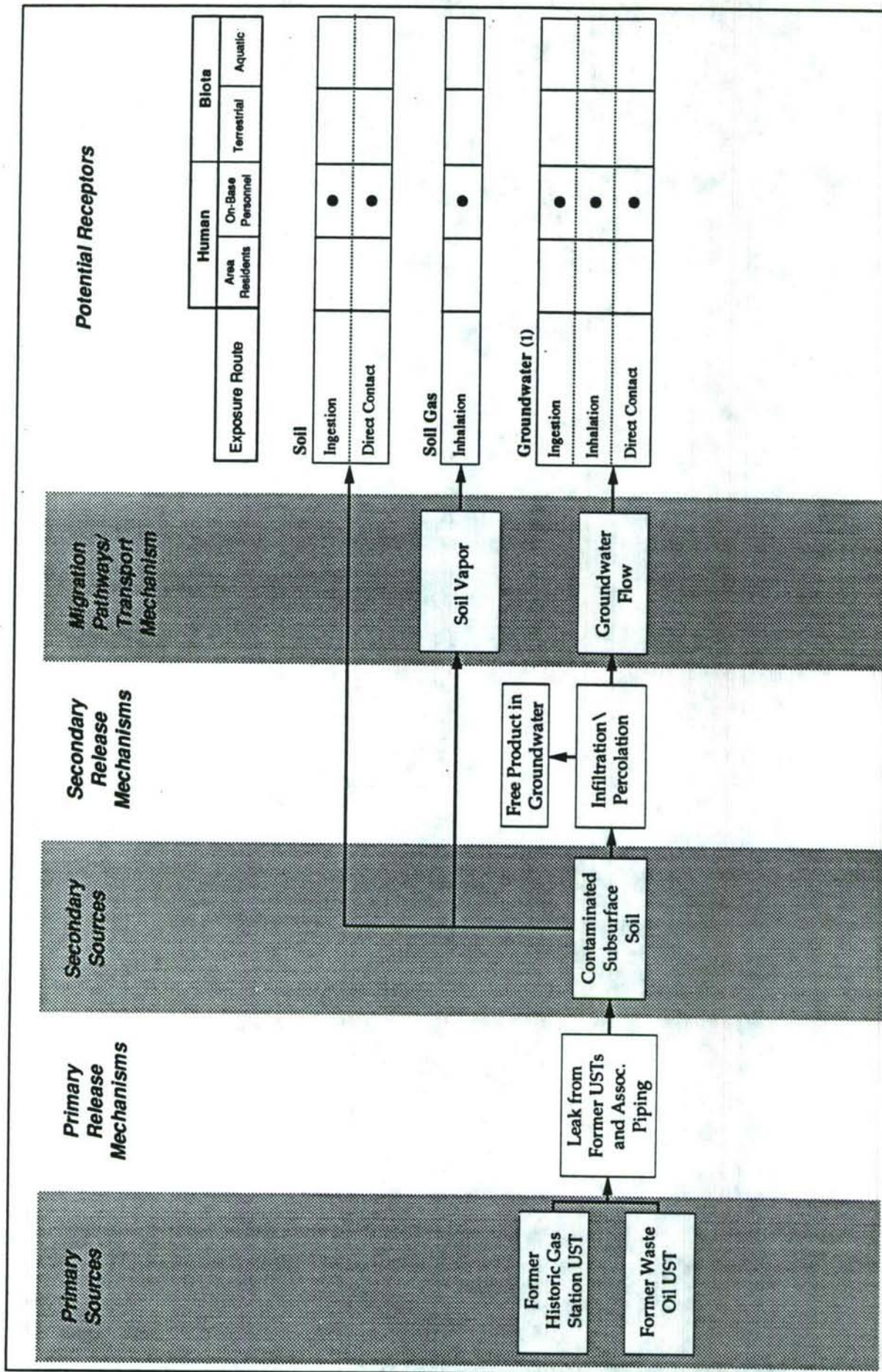
The migration pathways/transport mechanisms appear to be groundwater flow of dissolved contaminants, contaminant volatilization into soil gas, and wind for contaminants adhering to excavated soil.

AOC 43J is within the southeastern edge of the proposed Army Reserve Enclave. Because of this, the human health exposure scenario shows the base personnel could be effected by the fuel-related contaminants through ingestion, direct contact, and inhalation of groundwater. However, this exposure pathway is highly unlikely due to the fact that the planned reuse of this area, as well as surrounding area, precludes the installation of a potable water supply well at or near this AOC. On-post personnel could be exposed to contaminated subsurface soil through accidental ingestion and direct contact. In addition, on-post personnel could be exposed to dust from contaminated subsurface soil via inhalation.

Based on the site conditions (fenced area and paved parking lot) and the depth to the identified soil and groundwater contamination, potential risks to ecological receptors is not anticipated.



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**FIGURE 8-1**  
**CONCEPTUAL MODEL FLOW DIAGRAM**  
**AOC 43J-HISTORIC GAS STATION J**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

**NOTE**

(1) = Assumes drinking water wells will be installed at the site in the future commercial/industrial applications.





TABLE 8-1  
CHEMICAL AND PHYSICAL PROPERTIES OF COMPOUNDS DETECTED<sup>1</sup>  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

CONTAMINANT	MOLECULAR WEIGHT	DENSITY (g/cm <sup>3</sup> )	WATER SOLUBILITY (mg/L)	VAPOR PRESSURE (mm Hg)	HENRY'S CONSTANT, H <sub>c</sub> (atm m <sup>3</sup> mol <sup>-1</sup> )	ORGANIC CARBON PARTITION COEFFICIENT K <sub>oc</sub> (mL/g)
VOLATILE ORGANIC COMPOUNDS						
1,2-DICHLOROETHANE	98.98	1.28	8.52E+03	6.40E+01	9.78E-04	1.40E+01
BENZENE	78.12	1.87	1.75E+05	9.52E+01	5.59E-03	8.30E+01
CARBON TETRACHLORIDE	153.82	1.58	7.57E+02	9.00E+01	2.41E-02	4.39E+02
ETHYLBENZENE	106.16	0.87	1.52E+02	7.00E+00	6.43E-03	1.10E+03
TOLUENE	92.13	0.86	5.35E+02	2.81E+01	6.37E-03	3.00E+02
XYLENES <sup>2</sup>	106.16	0.88	1.75E+02	6.60E+00	5.10E-03	8.30E+02
SEMIVOLATILE ORGANIC COMPOUNDS						
1,2-DICHLOROBENZENE	147.01	1.3	1.00E+02	1.00E+00	1.70E-03	1.70E+03
2-METHYLNAPHTHALENE	142.2	1.02	2.54E+01	NA	NA	8.50E+03
o-CRESOL	108.14	1.03	2.50E+04	2.43E-01	1.50E-06	NA
p-CRESOL	108.14	1.01	NA	1.14E-01	NA	NA
NAPHTHALENE	128.2	0.98	3.17E+01	2.30E-01	1.15E-03	1.30E+03
PHENANTHRENE	178.2	1.03	1.00E+00	6.80E-04	1.59E-04	1.40E+04
PYRENE	202.3	1.27	1.30E-01	2.50E-06	5.04E-06	3.80E+04

Notes:

1. Primary Source: USEPA, 1990. "Basics of Pump-and-Treat Ground-Water Remediation Technology." Robert S. Kerr, Environmental Research Laboratory, Ada, OK. EPA/600/8-90/003.

2. Data presented is for o-xylene.

Aubrey, D.C., 1993. "Encyclopedia of Chemical Technology," Fourth Edition. John Wiley and Sons, New York, NY.

Verschuere, Karel, 1983. "Handbook of Environmental Data on Organic Chemicals." Van Nostrand Reinhold Company, Inc.

Howard, Philip, 1990. "Handbook of Environmental Fate and Exposure Data for Organic Chemicals; Volume II, Solvents." Lewis Publishers, Inc.

atm m<sup>3</sup> mol<sup>-1</sup> =

g/cm<sup>3</sup> = gram per cubic centimeter

K<sub>oc</sub> =

mg/L = milligram per liter

mL/g =

mm Hg =

NA = Not available



**TABLE 8-2**  
**MOBILITIES OF INORGANIC ELEMENTS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

Relative Mobility	Environment		
	Oxidizing (pH 5 to 8)	Oxidizing (pH <4)	Reducing
Highly mobile	Anions, B, Mo	Anions, B	Anions
Moderately mobile	Ca, Na, Mg, Sb, As, V, Zn, Be	Ca, Na, Mg, Pb, Zn, Cu, Hg, Co, Ni, V, As, Mn, Cd, Sb	Ca, Na, Mg, Ba, Mn
Slightly mobile	K, Ba, Mn, Pb, Cu, Cd, Ni	K, Ba, Cr	K, Fe <sup>2+</sup>
Immobile	Fe, Al, Cr, Hg	Fe, Al	Fe <sup>3+</sup> , Al, Cu, Zn, Pb, Cr, V, Ni, As*, Sb, Cd, Hg, Ba

\*Mobile in slightly reducing conditions.

As = Arsenic  
Al = Aluminum  
B = Boron  
Ba = Barium  
Be = Beryllium  
Ca = Calcium  
Cd = Cadmium  
Co = Cobalt  
Cr = Chromium  
Cu = Copper  
Fe = Iron  
Hg = Mercury  
K = Potassium  
Mg = Magnesium  
Mn = Manganese  
Mo = Molybdenum  
Nd = Sodium  
Ni = Nickel  
Pb = Lead  
Sb = Antimony  
V = Vanadium  
Z = Zinc





## 9.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

### 9.1 OVERVIEW

A human health risk assessment has been conducted to evaluate potential health risks to individuals under current or foreseeable future site conditions at AOC 43J. The risk assessment is consistent with relevant guidance and standards developed by USEPA (USEPA, 1989b, 1991b,c, 1992a,b,c) and incorporates data from the scientific literature used in conjunction with professional judgment. Due to the urbanized nature of this site and the lack of exposure pathways, an ecological risk assessment was not conducted.

The assessment for AOC 43J consists of the following components:

- Selection of Chemicals of Potential Concern (CPCs)
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Uncertainty Evaluation
- Summary and Conclusions

AOC 43J is one of eighteen historic gas stations on the Main Post of Fort Devens. The station consisted of a pump island and a small gasoline pumphouse. The gas station had one 5,000-gallon UST, which was removed in 1992. Contaminated soil and a strong fuel odor were observed in the soil in the excavation of the removed UST. Both groundwater and bedrock were encountered in the excavation at approximately 8 feet bgs. Physical obstructions in the area prevented additional lateral soil removal. Although contaminated soil was still present, the excavation was backfilled. Approximately 50 feet east of the historic gas station, a 1,000-gallon waste oil UST was excavated. Here also, not all of the contaminated soil was removed because it extended to a depth and width beyond the scope of the UST removal program.

At the present time, the area around AOC 43J is used as a vehicle storage yard, and the associated buildings (Buildings 2446 and 2479) serve as a maintenance facility for the 10th Special Forces Unit of the Army. Following base closure, the

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Army will retain AOC 43J as part of the Army Reserve Enclave. AOC 43J is located on a portion of the Main Post to be retained by the Department of defense after the closure of Fort Devens in 1995. It will be part of the Army Reserve Enclave that will provide facilities support to the Army Reserve organization at Fort Devens. The Enclave will also contain facilities for the active Army component that will remain on Fort Devens to support the reserve training activities (Vanasse Hangen Brustlin, Inc., 1994). The Army expects to demolish the two maintenance facility buildings and expand the use of AOC 43J as a storage yard.

Although AOC 43J is designated to remain within the Army Reserve Enclave, it cannot be ruled out that the site might be developed for commercial or industrial use in the future. According to the Devens Reuse Plan (Vanasse Hangen Brustlin, Inc., 1994), development of certain tracts of land at Devens will occur in various phases. In this risk assessment, certain exposure scenarios (such as the groundwater exposure pathway) have been developed to address the possibility of commercial/industrial use of AOC 43J.

AOC 43J will be evaluated as a source area, consisting of the area in the immediate vicinity of the two removed USTs, and a perimeter area, representing the remainder of the AOC.

### 9.2 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

The first step in the risk assessment was to collect, summarize, and analyze site data to identify those chemicals present in environmental media as a result of potential sources at AOC 43J. Site-related chemicals that were selected for risk evaluation are referred to as CPCs and represent those chemicals present as a result of past activities at AOC 43J.

Contaminants associated with AOC 43J are present in groundwater and subsurface soil. Surface soil contamination is not of concern because the surface of AOC 43J is either paved or the surface soil was removed as part of the UST removals during previous activities and replaced with clean fill. Subsurface soils are evaluated as two separate data sets, one consisting of samples associated with the source area and the other of samples associated with the perimeter area. For

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the human health risk assessment, subsurface soil was defined as extending from 1 to 15 feet bgs.

Groundwater samples from a set of wells associated with the source area and a set of wells downgradient of the source area were also analyzed. Analytical data from unfiltered and filtered samples in Rounds Five and Six are used for the evaluation. These sampling rounds were chosen because they included all of the existing and RI monitoring wells which best represented contaminant concentrations at AOC 43J. These rounds were separated by more than 90 days and represent seasonal changes in water levels.

Table 9-1 lists the sample locations providing data for subsurface soil and groundwater. All appropriate soil data taken above 15 feet bgs from sample locations at the source and perimeter areas are included in the evaluation. The groundwater data sets include all monitoring wells except those identified as cross-gradient wells. The procedures used to evaluate and summarize data and to screen data for the selection of CPCs are discussed below.

#### **9.2.1 Data Summary Procedures**

Prior to selecting CPCs, the analytical data were grouped into the data sets defined on Table 9-1. The sampling programs are described in Subsection 5.3.5. Samples were analyzed as discussed in Subsection 5.3.6. The following steps, which are in accordance with USEPA (1989b) guidance, were used to summarize the analytical data for this risk assessment:

- Data were summarized by environmental medium (for example, subsurface soil). All chemicals detected in at least one sample were identified.
- Frequency of detection was calculated as the number of samples in which the chemical was detected, over the total number of samples collected. Duplicate samples were considered as one data point for determining frequency of detection.
- The maximum and minimum detected concentration for each chemical was reported. For this determination, any duplicate

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samples were considered individually to ensure that the reported maximum or minimum concentration was an actual measured concentration, and not the average of two samples.

- Duplicate samples were averaged together and the averaged value was used to represent the concentration for that location, for the purpose of calculating the arithmetic mean.
- The arithmetic mean was calculated for each chemical using the detected concentration(s), or using one-half the sample quantitation limit (SQL) for the nondetect sample(s). Duplicate samples for a given sampling point were also averaged in this manner if a chemical was detected in only one sample of a duplicate pair.
- Because the data sets for AOC 43J consist of 15 samples or fewer, a 95 percent upper confidence limit (UCL) on the arithmetic mean was not calculated. "Supplemental Guidance to RAGS: Calculating the Concentration Term" (USEPA, 1992b) states that data sets with fewer than 10 samples provide poor estimates of the true mean, with the UCL frequently being greater than the highest measured concentration. Although data sets with 10 to 20 samples are said to provide a somewhat better estimate (USEPA, 1992b), it was determined in this case that the 95 percent UCLs on the means often exceeded the measured maximums. Therefore, arithmetic means and maximums were judged to be better estimates of possible exposure concentrations and were used instead of percent UCLs.

Summary sampling data for the source area and perimeter subsurface soil data sets and the source area and downgradient groundwater data sets for AOC 43J are presented in Table 9-2. The data screening procedures described below were applied to the summary data to select CPCs.

### 9.2.2 Data Screening Procedures

The procedures used for selection of CPCs, based on USEPA (1989b) guidance are described below. The results are indicated in Table 9-2.

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- If a chemical was determined to be an artifact, in Subsection 7.1.1 and 7.1.2, either due to laboratory or field cross-contamination, it was eliminated as a CPC.
- The summary data were also screened to eliminate naturally occurring inorganic analytes present at levels within background concentrations. The development of the background data sets is described in Subsection 4.3 of this report

If all detected concentrations of an inorganic analyte in soil or groundwater samples were within the range of basewide background concentrations for that medium, that chemical was assumed to be present at naturally occurring levels and was eliminated as a CPC. If, however, the maximum concentration of an inorganic exceeded the maximum basewide background concentration, that chemical was selected as a CPC and carried through the risk assessment. It should be noted that this is a conservative, non-statistical approach, and it does not indicate whether there is a statistically significant difference between the site and background concentration distributions.

- An assessment of essential nutrients was also performed to eliminate from the risk assessments those chemicals unlikely to result in adverse effects at low concentrations. Chemicals considered to be essential human nutrients include calcium, magnesium, potassium, and sodium.

CPCs retained in the selection process for the data sets are presented in Table 9-2. In addition, chemicals not selected for quantitative evaluation are noted, along with the reason for their elimination.

### **9.3 EXPOSURE ASSESSMENT**

The following subsections describe the exposure pathways evaluation for the human health risk assessment at AOC 43J.

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### 9.3.1 Human Exposure Pathways

An exposure assessment was conducted to identify the potential pathways by which human populations may be exposed to chemicals at AOC 43J and to provide quantitative evaluations of those exposures.

An exposure pathway (i.e., the sequence of events leading to contact with a chemical) generally consists of four elements:

- (1) A source and mechanism of chemical release to the environment;
- (2) A retention or transport medium for the released chemical;
- (3) A point of potential human contact with the impacted medium (i.e., the exposure point); and
- (4) A route of exposure (ingestion or dermal contact, for example) for a potential receptor.

When all four of these elements are present, an exposure pathway is considered "complete." In the risk assessment, only complete exposure pathways are evaluated. The exposure assessment is performed to identify complete pathways at AOC 43J, and it draws on information regarding the source, fate and transport of chemicals, and information on human populations potentially exposed to chemicals in environmental media.

In evaluating potential human exposure pathways, exposures under both current and potential future site uses and surrounding land use conditions were evaluated. Current land use conditions were evaluated to consider actual or possible exposures. Future site land use conditions were considered to address exposures that may occur as a result of any future activities or land use changes.

Future site and surrounding land use conditions at AOC 43J were assumed to be similar to current conditions. AOC 43J is located within the proposed Army Reserve Enclave in the central portion of the Main Post. The Enclave is one of several areas that the Army will retain after base closure (Vanassee Hangen Brustlin, Inc., 1994). The Army plans to use AOC 43J as a vehicle storage yard

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after base closure. The two buildings on the site (Building 2446 and 2479) will be removed and the surface paved. It is also possible that at some time in the future, the site would be developed for commercial or industrial use. Buildings might be constructed on the site at some time in the future, and utility lines in the area may be worked on at any time, either for repair or as part of future building construction.

Possible exposure pathways encompassing both current and future conditions are presented in Table 9-3, and are discussed below.

**Soil Pathway.** Under both current and future land use, contact with subsurface soil could occur if excavation activities such as utility line repair or building construction were to take place. Two receptors were chosen for evaluation. One is a utility/maintenance worker engaged in periodic repair activities. The second is a construction worker involved in building activities on site. The two principal routes by which workers could be exposed to chemicals in soil are ingestion and dermal contact. Following USEPA Region I guidance, the dermal route will not be evaluated quantitatively due to a lack of adequate dermal absorption information for the CPCs at the site. This approach will likely underestimate the risk associated with the VOCs and SVOCs detected in subsurface soil. However, the effects from inorganics would be expected to be negligible due to the poor absorption of inorganics through the skin. An additional exposure route, the inhalation of volatile compounds from soil or the shallow groundwater or of soil particles entrained in air (dust), is discussed under the Air Pathway below.

**Groundwater Pathway.** There is no current use of groundwater at AOC 43J. AOC 43J is to be located within the proposed Army Reserve Enclave in the central portion of the Main Post, which is one of several areas that will be retained by the Army after base closure (Vanasse Hangen Brustlin, Inc., 1994). There are existing supplies of water on the base and it is unlikely that the groundwater at the site would be extracted for future use. The groundwater is shallow (approximately 9 feet bgs) and not capable of producing a sufficient quantity of water flow for regular use. However, because future use of the groundwater cannot be ruled out, a future commercial/industrial worker using groundwater at the site as a drinking water source was selected as a receptor. Although unlikely, a future business might install a well on the site for use as



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drinking water supply. Ingestion of groundwater as drinking water is the exposure route evaluated.

**Air Pathway.** Air could be a contact medium if VOCs present in the soil or groundwater volatilize into the ambient air or if airborne particulates containing chemicals are generated from the soil. Any persons present at or near areas of release could be exposed via inhalation. Inhalation of volatiles released from soil will be evaluated quantitatively for the utility/maintenance worker and the construction worker. Inhalation of soil contaminants entrained on dust generated during a large-scale construction project is of concern for the construction worker. Dust generated during soil excavation is not considered to represent a significant source for the utility/maintenance worker and will not be evaluated. Because the depth to groundwater at AOC 43J is approximately 9 feet, excavations at the site may expose the surficial aquifer. Any volatile contaminants present in the exposed water may volatilize into outdoor air and potentially contaminate the breathing space of workers in the excavation; therefore inhalation of volatiles released from groundwater will be evaluated for both utility and construction workers. Inhalation of volatiles migrating into building foundations is not of current concern as the existing buildings are built on slabs, but could provide a future route of exposure if buildings with foundations were constructed on site. This route will be evaluated qualitatively in the risk characterization section by comparison to MADEP MCP GW-2 standards, which were developed to assess groundwater that is considered to be a potential source of vapors to indoor air.

### 9.3.2 Estimation of Exposure

To quantitatively estimate the magnitude of exposures and thus, the risks that may be experienced by an individual, the concentration of the CPC in the contact medium must be known or estimated. This concentration is referred to as an exposure point concentration (EPC). To estimate exposures, the EPC is combined with assumptions on the rate and magnitude of chemical contact. The determination of EPCs for each pathway is described below.

USEPA Region I has adopted the approach developed in "Supplemental Guidance to RAGS: Calculating the Concentration Term" (USEPA, 1992b) which recommends using the 95 percent UCL on the arithmetic mean concentration as the exposure point concentration (USEPA, 1994a). However, the guidance points

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out that data sets with fewer than 10 samples per exposure area provide poor estimates of the true mean concentration, often exceeding the maximum concentration. For this reason, the maximum detected concentration and the arithmetic mean of all samples were used for AOC 43J as EPCs for estimating reasonable maximum and central tendency exposures, respectively.

Quantitative exposure estimates were derived by combining the EPCs with information describing the extent, frequency, and duration of exposure for the specific receptor. An overview of the approaches used to quantify exposures is given below, followed by specific details for potential exposure pathways. The approaches described in the following paragraphs to quantify exposures are consistent with guidance provided by USEPA (1989b,d; 1991b; 1992a,c).

In cases where a 95 percent UCL can be calculated, current USEPA Region I guidance requires the use of the 95 percent UCL combined with central tendency exposure parameters and with reasonable maximum exposure (RME) parameters (USEPA, 1994a). Because two concentration terms are being used in this risk assessment instead of a 95 percent UCL, exposures were quantified by estimating RME parameters in accordance with USEPA risk assessment guidance (USEPA, 1989b; 1991b).

The term RME is defined as the maximum exposure that is reasonably expected to occur at a site (USEPA, 1989b). The RME is intended to place a conservative upper-bound on the potential risks, meaning that the risk estimate is unlikely to be underestimated but it may very well be overestimated. The likelihood that this RME scenario may actually occur is small, due to the combination of conservative assumptions incorporated into the scenario. The RME estimate for a given pathway is derived by combining the maximum EPC of each chemical with reasonable maximum values describing the extent, frequency, and duration of exposure (USEPA, 1989b). The central tendency estimate combines the same exposure parameters with the arithmetic mean exposure point concentration. Many of the exposure parameter values used in this assessment have been defined by USEPA (1989b,d; 1991b) for the RME case.

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The general equation for calculating chemical intake is as follows:

$$\text{Intake} = \frac{(C \times CR \times RAF \times EF \times ED)}{BW \times AT \times CF}$$

where:

Intake	=	daily intake averaged over the exposure period
C	=	concentration of the chemical in the exposure medium
CR	=	contact rate for the medium of concern
RAF	=	relative absorption factor
EF	=	exposure frequency
ED	=	exposure duration
BW	=	body weight of the hypothetically exposed individual
AT	=	averaging time (for carcinogens, AT = 70 years; for noncarcinogens, AT = ED)
CF	=	units conversion factor (365 days/yr)

Specific equations for each exposure scenario are provided in the risk calculation spreadsheets in Appendix M. Standard parameters from USEPA guidance were used where appropriate in the intake equations. Table 9-4 delineates the parameters used in each scenario and lists a source for each. The parameters are discussed briefly below.

The contact rate reflects the amount of the medium contacted per unit of time or event. For incidental ingestion of soil, the contact rate is 480 mg soil per day for the utility/maintenance worker and the construction worker (USEPA, 1991b). A fraction-ingested variable can be used to account for the amount of soil ingested daily that is assumed to come from the area of concern. It was conservatively assumed that all soil ingested daily would originate at AOC 43J. The contact rate for inhalation exposure is 4.8 m<sup>3</sup> of air per hour or 38.4 m<sup>3</sup> per workday for the utility/maintenance worker and the construction worker, based on a heavy activity rate (USEPA, 1989d). The contact rate for ingestion of groundwater is one liter per day, assuming half an individual's daily water intake occurs at work (USEPA, 1991b).

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The relative oral absorption factor represents the ratio of a chemical's bioavailability (i.e., ability to be absorbed and potentially exert an effect) when in an environmental matrix to its bioavailability when administered in the experimental dose-response study from which the toxicity criterion for that chemical was derived. The relative oral bioavailability factor is applied to account for the potentially reduced bioavailability of a chemical when ingested in a soil matrix, compared to when experimentally administered in a food mash, water or a solvent medium. In keeping with the conservative nature of this assessment, a relative oral bioavailability of 100% (or 1.0) was assumed for all chemicals.

The EPCs for volatiles released from soil into the air were calculated by applying a soil-to-air volatilization factor to the maximum and mean soil EPCs. The soil-to-air volatilization factor was developed using the equation presented in "Risk Assessment Guidance for Superfund: Volume 1-Human Health Evaluation Manual (Part B)" (RAGS, Part B) (USEPA, 1991c) and revised in 1992 (USEPA, 1992d). Table 9-5 presents the calculation of volatilization factors for CPCs at the source and perimeter areas.

EPCs for volatile contaminants released from exposed groundwater into excavation areas is calculated using a simple box model. The model assumes the placement of a hypothetical "box", 2 meters in height, above an excavation of a defined length and width (10 meters x 10 meters), containing a defined volume of contaminated water within the excavation (water depth of 3 meters). Air is presumed to move through the "box" (across the surface of the excavation) at a defined rate. Conservatively, all VOCs present within the volume of water are assumed to volatilize into the "box" within a 24 hour day, with 50 percent of volatilization assumed to occur within the 8 hour workday. The resultant air concentrations calculated will be used as EPCs in the quantitative risk assessment. The assumptions, equations, and calculations are presented in Table 9-6.

The body weight used for the utility/maintenance, construction, and commercial/industrial workers is 70 kg, the standard default value for adult body weight (USEPA, 1991b).

An exposure frequency and duration of 10 days per year (two work-weeks) for five years was assumed for the utility/maintenance worker. The construction worker was assumed to work five days a week for 18 weeks, or 90 days, for one

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year. The standard default values for exposure frequency and duration were used for commercial/industrial exposure (250 days per year for 25 years) (USEPA, 1991b).

The averaging time for lifetime exposure, used for developing intake to evaluate carcinogenic risk, was 70 years (USEPA, 1991b). Averaging time for noncarcinogenic risk was the actual exposure duration. For the construction worker, intake is averaged over the 90 days of actual exposure (0.25 years) rather than one year.

### 9.4 TOXICITY ASSESSMENT

The objective of the toxicity assessment is to define the relationship between the dose of a substance and the likelihood that a toxic effect, either carcinogenic or noncarcinogenic, will result from exposure to that substance. Dose-response values were identified and used to estimate the likelihood of adverse effects as a function of human exposure to an agent. Dose-response summaries are presented in Tables 9-7 through 9-10.

There are two types of dose-response values used in this risk assessment: cancer slope factors (CSFs) and reference doses (RfDs). USEPA has derived CSFs and RfDs to evaluate carcinogenic risks and noncarcinogenic (systemic) effects, respectively. The definitions of CSFs and RfDs, as stated in USEPA guidance are:

- Cancer Slope Factor - a plausible upper bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The CSF is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen (USEPA Class A or B carcinogens) (USEPA, 1989b).
- Chronic Reference Dose - an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during

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a lifetime (e.g., as a Superfund program guideline, seven years to a lifetime) (USEPA, 1989b).

- Subchronic Reference Dose - an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a portion of a lifetime (e.g., as a Superfund program guideline, two weeks to seven years) (USEPA, 1989b).

In addition, because the toxicity and/or carcinogenicity of a compound can depend on the route of exposure (e.g., oral or inhalation), unique dose-response values (e.g., CSFs and RfDs) have been developed for the oral and inhalation exposure routes. The utility/maintenance worker and the construction worker were evaluated for subchronic exposures (five years and one year, respectively), while the commercial/industrial worker (25 years) was evaluated as a chronic exposure.

The primary source for identifying dose-response values is the USEPA Integrated Risk Information System (IRIS) (USEPA, 1995a). If no information is found in IRIS, the USEPA Health Effects Assessment Summary Tables (HEAST) (USEPA, 1994c) are used. If appropriate dose-response values are not available from either of these two sources, other USEPA sources are consulted (e.g., the USEPA Environmental Criteria and Assessment Office [ECAO]).

RfDs have been published for only a few of the PAHs. To evaluate the noncarcinogenic effects of PAHs without published values, the RfD for naphthalene is used as a surrogate value.

No dose-response values are available for some of the CPCs. Therefore, risks associated with these chemicals could not be quantitatively evaluated although they are retained as CPCs. Chemicals not quantitatively evaluated for AOC 43J include lead and TPHCs. These chemicals will be evaluated qualitatively in the risk characterization section.

In addition, no inhalation RfDs are available for CPCs. HEAST and IRIS do, however, list reference concentrations for a number of the CPCs. Risks for these CPCs were evaluated by developing an average daily air concentration instead of

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an inhalation dose. The equation for the average daily air concentration, shown on the spreadsheets in Appendix N, is the air concentration times the exposure time and duration divided by the averaging time.

### 9.5 RISK CHARACTERIZATION

In this final step of the risk assessment process, the exposure and toxicity information are integrated to develop both quantitative and qualitative evaluations of risk. To quantitatively assess risks associated with CPCs in an environmental medium, the average daily intakes calculated in the Exposure Assessment are combined with the dose-response criteria presented in the Toxicity Assessment. The methodology used to quantitatively assess risks is described below.

USEPA (1989b) has developed guidance for assessing the potential risks to individuals from exposure to carcinogenic and noncarcinogenic chemicals. For exposures to a chemical exhibiting carcinogenic effects, an individual upper bound excess lifetime cancer risk is calculated by multiplying the estimated daily intake by the relevant CSF. The resulting risk estimate is an estimate of the probability of contracting, not dying from, cancer as a result of exposure to the potential carcinogen over a 70-year lifetime under the specified exposure conditions. A risk level of  $1 \times 10^{-6}$ , for example, represents an upper bound probability of one in one million that an individual will contract cancer. The upper bound cancer risk estimates provide estimates of the upper limits of risk, and the risk estimates produced are likely to be greater than the 99th percentile of risks faced by actual receptors (USEPA 1992a). To assess the upper bound individual excess lifetime cancer risks associated with simultaneous exposure to all carcinogenic chemicals of concern, the risks derived from the individual chemicals are summed within each exposure pathway. This approach is consistent with the USEPA's guidelines for evaluating the toxic effects of chemical mixtures (USEPA 1989b). It will overestimate risk if maximum concentrations occur in different locations and they are used as EPCs.

The relative significance of carcinogenic risk estimates was evaluated by comparison to a target risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  established by USEPA (USEPA, 1989b). USEPA's guidelines state that when the total incremental

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carcinogenic risk for an individual resulting from exposure at a hazardous waste site is within the range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$ , a decision about whether to take action or not is a site-specific decision. An additional criterion used for comparison is the MADEP MCP target cancer risk level of  $1 \times 10^{-5}$  (MADEP, 1995). Although the MADEP MCP is not an ARAR for AOC 43J, risk estimates for exposure to mean site concentrations are compared to the MADEP MCP target risk level.

Unlike carcinogenic effects, noncarcinogenic effects are not expressed as incidence probabilities. Rather, potential noncarcinogenic impacts were evaluated by means of a hazard quotient/hazard index technique as recommended by USEPA (1989b). To assess impacts associated with noncarcinogenic exposures, the ratio of the daily intake to the reference dose is calculated for each noncarcinogenic chemical to derive a hazard quotient (HQ). In general, HQs that are less than 1 indicate that the associated exposure is not likely to result in any adverse health effects, while HQs greater than 1 indicate that adverse health effects may occur. The effects from simultaneous exposures to all CPCs were computed by summing the individual HQs within each exposure pathway. This sum, known as the hazard index (HI), serves the same function for exposures to a mixture as the HQ does for exposure to an individual compound.

HI's for both mean and maximum site concentrations are compared to a target level of 1, established by USEPA; HI's for exposure to mean site concentrations are compared to a MADEP MCP target level of 1. HI's greater than 1 indicate the potential for the occurrence of adverse health effects. A conclusion should not be categorically drawn, however, that all HI's greater than 1 are unacceptable; this is because of the multiple conservative assumptions built into the exposure estimates and toxicity characterization. In cases where an HI is greater than 1, the CPCs are segregated into categories based on target organ/critical effect (e.g., liver, skin, etc.) in accordance with USEPA guidance (USEPA 1989b).

The risk calculations for the source and perimeter areas and groundwater are presented in Appendix N. The risk estimates are summarized in Table 9-11 and are discussed below.

**Subsurface Soil.** Potential health risks associated with future exposures to subsurface soil were quantified by receptor and area. At the source area, the total cancer risk to the utility/maintenance worker, assuming exposure to mean

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concentrations is  $1 \times 10^{-6}$ , which is at the lower end of the USEPA risk range and below the MADEP MCP target level. The estimated risk for exposure to maximum concentrations is also  $1 \times 10^{-6}$ . For the construction worker at the source area, the total cancer risk assuming exposure to mean concentrations is  $2 \times 10^{-6}$ , which is within the USEPA risk range and below the MADEP MCP target level. The estimated risk for exposure to maximum concentrations is also  $2 \times 10^{-6}$ , within the USEPA risk range. The risk levels for the utility/maintenance and construction worker scenarios as a result of inhalation of volatiles released from groundwater. Individual risks for each volatile, however, do not exceed  $1 \times 10^{-7}$ .

Estimated noncarcinogenic HIs for exposure to mean concentrations of soil contaminants for the source area are 0.02 for the utility/maintenance worker, and 0.8 for the construction worker; both are below both the USEPA and MADEP MCP target level of one. At maximum concentrations, HIs for the source area are 0.03 for the utility/maintenance worker, again below the USEPA target level, and 1 for the construction worker, at the target level. The HI of 1 for the construction worker results from ingestion of arsenic and inhalation of volatiles released from groundwater. Individual HQs for each of these CPCs, however, are below 1.

At the perimeter area, the total cancer risk for the utility/maintenance worker, assuming exposure to mean concentrations is  $4 \times 10^{-7}$ , which is below the USEPA risk range and the MADEP MCP target level. The estimated risk for utility/maintenance worker exposure to maximum concentrations is  $7 \times 10^{-7}$ , again below the USEPA risk range. For the construction worker at the perimeter area, the total cancer risk assuming exposure to mean concentrations is  $7 \times 10^{-7}$ , which is below the USEPA risk range and the MADEP MCP target level. The estimated risk for exposure to maximum concentrations is  $1 \times 10^{-6}$ , within the USEPA risk range, and is based on ingestion of arsenic.

Estimated noncarcinogenic hazards for exposure to mean concentrations of soil contaminants for the perimeter area are 0.02 for the utility/maintenance worker, and 0.8 for the construction worker; both are below the USEPA and MADEP MCP target level of 1. At maximum concentrations, HIs for the perimeter area are 0.04 for the utility/maintenance worker and 1 for the construction worker. The predominant contributors to the HI of 1 for the construction worker are arsenic (HQ of 0.7) and iron (HQ of 0.6) by the ingestion route.

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It is appropriate to segregate the effects of these analytes based on differences in mechanism of action, toxic endpoint, or target organ. The two analytes may be segregated based on target organ and toxic effect, even though both are presumed to act by the same basic mechanism of action, the inhibition of sulfhydryl-containing proteins. Chronic arsenic exposure results in peripheral nervous system effects including parasthesias, progressive muscular weakness, and sensory loss. Chronic oral iron exposure is associated with liver necrosis and disturbed liver function which results from liver peroxidation due to the accumulation of excess unbound iron in the liver. Since the two metals produce effects in different organ systems and since the HQ for neither exceeds one, noncarcinogenic effects would not be expected to occur.

Because lead does not have a published dose-response value, it is evaluated by comparison to the USEPA screening level of 400 mg/kg for lead in residential soil (USEPA, 1994b). Maximum concentrations of lead at the source and perimeter areas are 86 mg/kg and 54 mg/kg, respectively. Neither concentration exceeds the USEPA screening level.

Toxicity values are also unavailable for TPHC, although the toxicity of some TPHC components (such as benzene and PAHs) has been evaluated. TPHC was evaluated by comparing concentrations to MADEP MCP Method 1 S-2 soil standards for TPHC. MCP soil standards were developed to consider both the potential risk from direct exposure to the contaminant in the soil and potential impact of the contaminant on groundwater at the site. The lowest identified standard was used for comparison. Maximum concentrations for TPH in subsurface soil at the source and perimeter areas are 1,880 mg/kg and 566 mg/kg, respectively. Both are below the MADEP MCP S-2 standard of 2,500 mg/kg, which applies to all three groundwater categories associated with category S-2 soil.

**Groundwater.** Potential risks associated with use of site groundwater as a potable water source in the future was evaluated for both unfiltered and filtered data sets for source area wells and downgradient wells. Filtered groundwater was analyzed for inorganics only, but potential risks for the filtered data were estimated, assuming that all organic CPCs detected in unfiltered groundwater were present in filtered groundwater.



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For unfiltered source area groundwater, the estimated cancer risk assuming exposure to mean concentrations is  $3 \times 10^{-4}$ , which is above the USEPA risk range and the MADEP MCP target level. A substantial contributor to the risk (92 percent) is arsenic, with an individual risk of  $2 \times 10^{-4}$ . Benzene and carbon tetrachloride contribute the remainder (4 percent and 3 percent, respectively), although neither individual risk exceeds the USEPA target risk range. The estimated risk, assuming exposure to maximum concentrations, is  $6 \times 10^{-4}$ , a level exceeding the USEPA target risk range. Arsenic (86 percent), carbon tetrachloride (7 percent), and benzene (5 percent) are the primary contributors, but only arsenic has an individual risk ( $5 \times 10^{-4}$ ) which exceeds the USEPA target risk range.

Estimated cancer risk for exposure to mean concentrations of filtered groundwater at the source area is  $2 \times 10^{-4}$ , which slightly exceeds the upper limit of the USEPA risk range and is above the MADEP MCP target level. Arsenic is the primary contributor to the risk (90 percent), with benzene making a smaller contribution (5 percent). The individual cancer risk for arsenic ( $2 \times 10^{-4}$ ) is above the USEPA range, while that of benzene ( $1 \times 10^{-5}$ ) is within the range. The estimated risk assuming exposure to maximum concentrations is  $5 \times 10^{-4}$ , a level exceeding the USEPA target risk range. Arsenic (84 percent), benzene (6 percent), and carbon tetrachloride (9 percent) are the major contributors to risk. The individual risk for arsenic ( $4 \times 10^{-4}$ ) exceeds the USEPA target risk range, while the risks for benzene and carbon tetrachloride ( $3 \times 10^{-5}$  and  $5 \times 10^{-5}$ , respectively) are within the range.

Noncarcinogenic risk for source area unfiltered groundwater is estimated with an HI of 25, assuming exposures to mean concentrations, and an HI of 53 for exposures to maximum concentrations. The cumulative HI in both cases exceeds the USEPA target level for noncarcinogens of one. Based on mean concentrations, the primary contributors to noncarcinogenic risk are manganese at 76 percent, benzene at 13 percent, and arsenic at 5 percent. Based on maximum concentrations, the contributors to noncarcinogenic risk are manganese at 67 percent, benzene at 18 percent, arsenic at 5 percent, and iron and carbon tetrachloride at 3 percent.

Noncarcinogenic risk for filtered source area groundwater is estimated with an HI of 24, assuming exposures to mean concentrations, and an HI of 52 for exposures

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to maximum concentrations. The cumulative HI in both cases exceeds the USEPA level of 1. The primary contributors to the noncarcinogenic risk based on mean concentrations are manganese at 78 percent with an HQ of 19 and benzene at 13 percent with an HQ of 3. For maximum concentrations, the contributors to noncarcinogenic risk are arsenic at 5 percent with an HQ of 2, manganese at 70 percent with an HQ of 36, and benzene at 19 percent with an HQ of 10.

For the source area, segregation of the cumulative HI based on differences in mechanisms of action, toxic endpoint or target organ affected by exposure to each of the contributors is possible, because each risk contributor produces effects in distinct organ systems. However, this segregation still resulted in individual HQs greater than 1 for both the average and the RME scenarios.

Estimated cancer risk for downgradient unfiltered groundwater is  $3 \times 10^{-5}$ , assuming exposure to mean concentrations of CPCs. The risk is within the USEPA risk range but slightly exceeds the MADEP MCP target level. Arsenic contributes 97 percent of the risk in this case and is the only CPC with an individual cancer risk exceeding  $1 \times 10^{-5}$ . For exposure to maximum CPC concentrations in downgradient unfiltered groundwater, the total cancer risk is  $7 \times 10^{-5}$ , which is also within the USEPA risk range. Arsenic contributes 95 percent of the risk and again is the only CPC with a cancer risk exceeding  $1 \times 10^{-5}$ .

For filtered downgradient groundwater, estimated cancer risk is  $6 \times 10^{-7}$  for exposure to mean concentrations of CPCs. The risk is below the USEPA risk range and the MADEP MCP target level. For exposure to maximum CPC concentrations in filtered downgradient groundwater, the total cancer risk is  $4 \times 10^{-6}$ , which is within the USEPA risk range.

For unfiltered downgradient groundwater, noncarcinogenic risk assuming exposure to mean concentrations is represented by an HI of 2, exceeding the USEPA and the MADEP MCP target levels of 1. Manganese contributes 77 percent of the risk and is the only CPC with an HQ above 1. For exposure to maximum concentrations, the HI is estimated to be 7, exceeding the USEPA target level. In this case, manganese contributes 68 percent of the risk and again is the only CPC with an HQ above 1. Iron contributes 11 percent of the risk and benzene contributes 10 percent to the total risk.

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Noncarcinogenic risk assuming exposure to mean concentrations of filtered downgradient groundwater is estimated with an HI of 2, exceeding the USEPA and the MADEP MCP target level of one. Manganese contributes 88 percent of the risk with an HQ of 2. For exposure to maximum concentrations, the HI is estimated to be 6, exceeding the USEPA target level. In this case, manganese contributes 85 percent of the risk with an HQ of 5. Benzene adds 10 percent but has an HQ less than 1 (0.7).

For the downgradient groundwater, segregation of the cumulative HI based on differences in mechanisms of action, toxic endpoint or target organ affected by exposure to each of the contributors is possible, because each produces effects in distinct organ systems. However, this segregation still results in an individual HQ greater than 1 for the primary risk driver, manganese, in both the average and the RME scenarios.

Vapor migration of volatile contaminants from groundwater into existing on-site buildings was excluded as a possible route of exposure because on-site buildings are built on concrete slab foundations. To qualitatively evaluate whether vapor migration may represent a future risk, concentrations of volatiles in source and downgradient area groundwater were compared to MCP Method 1 GW-2 standards, which have been developed to assess groundwater that is considered to be a potential source of vapors to indoor air. The comparison is shown in Table 9-12. Only maximum concentrations of toluene, xylene, and carbon tetrachloride in source area groundwater exceed their respective GW-2 standards. Toluene, at 8 mg/L, and xylene, at 9 mg/L, both slightly exceed their GW-2 standard of 6 mg/L. The maximum detected concentration of carbon tetrachloride, 0.1 mg/L, also exceeds its MCP GW-2 standard of 0.02 mg/L. The maximum concentrations of all other VOCs in source area and downgradient are all below their respective GW-2 standard. If average groundwater concentrations were compared to the GW-2 standards, as required under the MCP, the average concentrations of all detected VOCs are equal to or below the GW-2 standards. Vapor migration into building foundations is not expected to pose a significant risk at AOC 43J.

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## 9.6 COMPARISON OF EPCs TO STANDARDS AND GUIDELINES

Federal and state drinking water standards and guidelines exist for many of the CPCs detected in source area and downgradient groundwater. Tables 9-13 and 9-14 contain comparisons of source area and downgradient groundwater EPCs to drinking water standards and guidelines, respectively.

As seen in Table 9-13, detected concentrations in the source area groundwater of the following CPCs exceed either a federal MCL, a USEPA drinking water guideline, a Massachusetts MCLs, or a Massachusetts drinking water guideline: benzene, ethylbenzene, toluene, carbon tetrachloride, chloroform, arsenic, cadmium, lead, and sodium. In addition, detected concentrations of aluminum, iron, and manganese exceed their respective federal or state Secondary MCLs (SMCLs) - standards set not for health reasons but economic or aesthetic reasons. Neither aluminum nor cadmium were detected in filtered samples.

In downgradient groundwater shown in Table 9-14, detected concentrations of the following CPCs exceed one or more of their drinking water standards or guidelines: benzene and chloroform. For benzene and chloroform, while the maximum detected concentrations exceed a respective standard or guideline, their average concentrations do not. In addition, detected concentrations of aluminum, iron, and manganese exceed their respective SMCLs. Aluminum was not detected in the filtered samples.

## 9.7 EVALUATION OF UNCERTAINTY

The interpretation of risk estimates is subject to a number of uncertainties as a result of conservative assumptions inherent in risk assessment. All quantitative estimates of risk are based on numerous assumptions, most intended to be protective of human health (i.e., conservative). As such, risk estimates are not truly probabilistic estimates of risk, but rather conditional estimates given a series of conservative assumptions about exposure and toxicity.

In general, sources of uncertainty are categorized into site-specific factors (e.g., variability in analytical data, modeling results, and exposure parameter assumptions) and toxicity factors. Toxicity information for many chemicals is very

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limited, leading to varying degrees of uncertainty associated with calculated toxicity values. Sources of uncertainty for calculating toxicity factors include extrapolation from short-term to long-term exposures, amount of data (e.g., number of studies) supporting the toxicity factors, consistency of different studies for the same chemical, and responses of various species to equivalent doses. Major sources of uncertainty and their potential effects (e.g., to over- or underestimate risks) for AOC 43J are presented in Table 9-15.

Arsenic is a CPC detected in groundwater and subsurface soil at AOC 43J. Use of the CSF for arsenic to estimate excess lifetime cancer risks is thought by many to overestimate the true risk. The oral CSF for inorganic arsenic is based on dose/response data for skin cancer incidence obtained by Tseng et al. (1968). Individuals in this study were exposed to high levels of inorganic arsenic in drinking water (170 micrograms per milliliter [ $\mu\text{g}/\text{ml}$ ]). Arsenic exposure was approximated based on estimates of water intake. Other exposure pathways contributing to total exposure, such as ingestion of fish, livestock, and plants were not assessed, potentially resulting in an underestimate of arsenic exposure. The oral slope factor was calculated using a model that assumes the dose/response curve is linear at low doses. Recent evidence suggests that arsenic, at low doses, may be largely detoxified by methylation, producing a non-linear dose/response curve (Goyer, 1991). In the study of Tseng et al. (1968), the overwhelming of the normal detoxification pathways, coupled with an underestimate of exposure, may have resulted in an overestimate of cancer risk.

The uncertainties summarized above have resulted in the USEPA IRIS file for inorganic arsenic reporting that, "the uncertainties associated with ingested inorganic arsenic are such that estimates could be modified downwards as much as an order of magnitude, relative to risk estimates associated with most other carcinogens" (IRIS, December 1993).

The noncancer risks associated with manganese in drinking water may also be overestimated in this risk assessment. The manganese drinking water RfD of  $5.00\text{E-}03$  mg/kg-day is based on a single epidemiological study conducted in Greece (Kondakis et al., 1989). Limitations with study design coupled with the lack of supporting studies may have resulted in a significant overestimate of the risks associated with drinking water ingestion of manganese. The critical study assessed neurological function in an adequate number of individuals residing in

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three geographically distinct areas of Greece, each area with significantly different levels of manganese endemic to the local water supply. The study failed to investigate and quantitate other dietary sources of manganese in the study groups. The levels of manganese in locally grown produce and livestock can be presumed to reflect the local concentration of manganese in the water supply (i.e., the high manganese area would also have local food with higher levels of manganese than the areas with lower levels of manganese in water). This study flaw may have resulted in the establishment of a drinking water RfD that is artificially low (i.e., overly protective). Additionally, the study assessed neurological function only in individuals older than 50 years of age. The neurological degeneration documented to be produced by high chronic manganese consumption is non-specific in nature and may in fact be produced by a number of other neurological diseases, such as Parkinson's Disease and Alzheimer's Disease, which increase in prevalence with age. The failure of this study to control for the presence of other neurological diseases or for patients with a family history of neurological disease lends uncertainty to the cause-and-effect relationship of manganese to the toxic endpoint assessed.

## 9.8 SUMMARY AND CONCLUSIONS

Potential health risks associated with exposure to subsurface soil at the source area and the perimeter area of AOC 43J were evaluated. The primary CPCs identified in soil were ethylbenzene, toluene, xylene, noncarcinogenic PAHs, and inorganic compounds. The exposure scenarios evaluated were for a utility/maintenance worker and a construction worker. Estimated carcinogenic risks did not exceed the USEPA risk range or MADEP MCP risk level. Similarly, potential noncarcinogenic risks did not exceed the USEPA and MADEP MCP target level.

Risks associated with exposure to unfiltered and filtered groundwater were evaluated for groundwater representing the source area and for groundwater identified as downgradient. The receptor evaluated was a future commercial/industrial worker. Estimated carcinogenic risks for unfiltered groundwater exceeded the USEPA target risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  for exposure to both mean and maximum concentrations of CPCs in source area groundwater ( $3 \times 10^{-4}$  and  $6 \times 10^{-4}$ , respectively). Arsenic was the primary contributor

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to the excess risk (exceeding  $1 \times 10^{-4}$  risk level). Assuming exposure to maximum concentrations, benzene and carbon tetrachloride produced individual risks above  $1 \times 10^{-5}$ . In unfiltered downgradient groundwater, estimated carcinogenic risks were within the USEPA target risk range.

Risks were estimated for commercial/industrial worker exposure to filtered groundwater assuming that concentrations of organic CPCs remain the same as in unfiltered groundwater. Estimated carcinogenic risks exceeded the USEPA risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  for exposure to both mean and maximum concentrations of CPCs in source area groundwater ( $2 \times 10^{-4}$  and  $5 \times 10^{-4}$ , respectively). Arsenic and benzene were the primary contributors to the excess risk for mean concentrations, while arsenic, benzene, and carbon tetrachloride were contributors at maximum concentrations. At both mean and maximum concentrations, only arsenic produced individual risks above  $1 \times 10^{-4}$ . In downgradient groundwater, exposure to both mean and maximum concentrations produced risks within the USEPA range ( $1 \times 10^{-5}$  and  $3 \times 10^{-5}$ , respectively).

If the modified CSF for arsenic was used to estimate excess lifetime cancer risks, then the cancer risks associated with exposure to both average and maximum concentrations of arsenic in unfiltered and filtered groundwater would fall below  $1 \times 10^{-4}$ .

Estimated noncarcinogenic risks exceeded the USEPA target level of 1 for both source area and downgradient unfiltered groundwater at mean and maximum concentrations. HIs for the source area are 25 and 53 for exposure to mean and maximum concentrations, respectively. Benzene, manganese, iron, and arsenic are the primary contributors for source area groundwater. HIs for downgradient groundwater are 2 and 7 for mean and maximum concentrations, respectively. Manganese and benzene are the primary contributors for downgradient groundwater. Individual HQs for the primary contributors in both source area and downgradient groundwater all exceed the USEPA target level of 1.

For filtered groundwater, estimated noncarcinogenic risks exceeded the USEPA target level of 1 for both source area and downgradient groundwater at mean and maximum concentrations. HIs for the source area are 24 and 52 for exposure to mean and maximum concentrations, respectively. Benzene and manganese are primary contributors at mean concentrations, while benzene, manganese and

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arsenic are the primary contributors for maximum concentrations of filtered source area groundwater. HIs for downgradient groundwater are 2 and 6 for mean and maximum concentrations, respectively. Manganese is the only contributor with an HQ exceeding 1.

A comparison of detected concentrations of CPCs in source area and downgradient groundwater to federal and state drinking water standards and guidelines showed several exceedances. In source area groundwater, the following CPCs were detected at concentrations above a federal or state standard or guideline: benzene, ethylbenzene, toluene, carbon tetrachloride, chloroform, arsenic, cadmium, lead, sodium, aluminum, iron, and manganese. In downgradient groundwater, detected concentrations of benzene, chloroform, aluminum, iron, and manganese exceed federal or state drinking water standards or guidelines.

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**TABLE 9-1**  
**SUMMARY OF SAMPLE LOCATIONS USED IN THE HUMAN HEALTH RISK ASSESSMENT**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

MEDIA	AREA	EXPLORATION	SAMPLE LOCATION	DEPTH (feet bgs)
Subsurface Soil <sup>1</sup>	Source Area	Site Investigation	43J-92-01X	5-6.2
		Remedial Investigation	XJB-94-03X	11-13
			XJB-94-06X	12-14
			XJB-94-08X	7-9
				9-11
			XJB-94-10X	7-9
			XJB-94-11X	7-9
				11-13
			XJB-94-12X	7-9
				11-13
	Perimeter Area	Supplemental Site Investigation	XJM-93-01X	10-12
			XJM-93-02X	5-7
		Remedial Investigation		10-12
			XJB-94-02X	5-7
				7-9
			XJB-94-05X	5-7
			XJB-94-07X	9-11
				11-13
			XJB-94-09X	7-9
				9-11
			XJB-94-13X	9-11
				11-13
			XJB-94-14X	11-13
			XJB-94-15X	7-9
			XJB-94-16X	7-9
Groundwater <sup>2</sup>	Source Area	Rounds 5 and 6	XJM-94-05X	Not Applicable
			XJM-93-03X	
			XJM-93-02X	
			2446-02	
			2446-03	
			2446-04	
	Downgradient Area	Rounds 5 and 6	XJM-94-07X	
			XJM-94-08X	
			XJM-94-09X	
			XJM-94-10X	

Notes:

<sup>1</sup> Subsurface soil is defined as soil between 1 and 15 feet bgs

<sup>2</sup> Unfiltered and filtered data from each sample location were used to develop separate data sets

bgs = below ground surface



TABLE 9-2  
CHEMICALS OF POTENTIAL CONCERN  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

	Range of SOLs	Frequency of Detection	Detected Concentrations		Mean of all Samples	Back- Ground	CPC?	Notes
			Minimum	Maximum				
SOURCE AREA SUBSURFACE SOIL (1 ~ 15 feet bgs) <sup>a</sup> (mg/kg)								
PAL METALS								
Aluminum	N/A	9/9	3950	9500	7145.6	18000	No	Background <sup>1</sup>
Antimony	1.09 - 1.09	2/9	2.01	3.28	1.0	0.5	Yes	
Arsenic	N/A	9/9	9.4	20	14.1	19	Yes	
Barium	N/A	9/9	15.3	28.7	20.1	54	No	Background <sup>1</sup>
Calcium	N/A	9/9	566	1450	963.2	810	No	Essential Nutrient <sup>2</sup>
Chromium	N/A	9/9	12.9	36	18.7	33	Yes	
Cobalt	1.42 - 1.42	9/9	5.99	9.84	7.7	4.7	Yes	
Copper	N/A	9/9	14.5	169	33.3	13.5	Yes	
Iron	N/A	9/9	12900	18000	15877.8	18000	No	Background <sup>1</sup>
Lead	N/A	10/10	6.7	86	18.0	48	Yes	Toxicity Value <sup>3</sup>
Magnesium	N/A	9/9	1680	4120	3536.7	5500	No	Background <sup>1</sup> , Essential Nutrient <sup>2</sup>
Manganese	N/A	9/9	252	828	489.9	380	Yes	
Nickel	N/A	9/9	23.2	36.9	29.5	14.6	Yes	
Potassium	N/A	9/9	561	1180	769.1	2400	No	Background <sup>1</sup> , Essential Nutrient <sup>2</sup>
Sodium	N/A	9/9	366	485	431.2	234	No	Essential Nutrient <sup>2</sup>
Vanadium	N/A	9/9	6.42	20.6	10.8	32.3	No	Background <sup>1</sup>
Zinc	N/A	9/9	21.7	99	40.4	43.9	Yes	
PAL SEMIVOLATILE ORGANICS								
2-Methylnaphthalene	0.049 - 0.5	6/9	0.093	7	1.3	NDB	Yes	
bis(2-Ethylhexyl)phthalate	0.62 - 6	2/9	1	2.8	1.1	NDB	No	Blank <sup>4</sup>
Di-n-butyl Phthalate	0.061 - 0.6	1/9	1.4	1.4	0.2	NDB	No	Blank <sup>4</sup>
Naphthalene	0.037 - 0.4	5/9	0.71	10	1.5	NDB	Yes	
Phenanthrene	0.033 - 0.2	1/9	0.5	0.5	0.08	NDB	Yes	
Pyrene	0.033 - 0.2	1/9	0.7	0.7	0.1	NDB	Yes	
PAL VOLATILE ORGANICS								
Xylenes	0.0015 - 0.0015	8/10	0.0063	100	30	NDB	Yes	
Acetone	0.017 - 8	1/10	0.044	0.044	0.9	NDB	No	Blank <sup>4</sup>
Chloroform	0.0009 - 0.4	1/10	0.0081	0.0081	0.04	NDB	No	Blank <sup>4</sup>
Ethylbenzene	0.0017 - 0.0017	7/10	0.0042	30	7.8	NDB	Yes	
Toluene	0.0008 - 0.0008	5/10	0.1	20	3.6	NDB	Yes	
Trichlorofluoromethane	0.0059 - 3	1/10	0.0082	0.0082	0.3	NDB	No	Blank <sup>4</sup>
OTHER								
Total Petroleum Hydrocarbons	NA	10/10	46.2	1880	519.2	NDB	Yes	Toxicity Value <sup>3</sup>
PERIMETER AREA SUBSURFACE SOIL (1 ~ 15 feet bgs) <sup>b</sup> (mg/kg)								
PAL METALS								
Aluminum	N/A	15/15	2800	13900	6932	18000	No	Background <sup>1</sup>
Antimony	1.09 - 1.09	1/15	2.21	2.21	0.7	0.5	Yes	
Arsenic	N/A	15/15	8.06	31	16.9	19	Yes	
Barium	N/A	15/15	6.56	49	19.8	54	No	Background <sup>1</sup>
Beryllium	0.5 - 0.5	1/15	0.723	0.723	0.3	0.81	No	Background <sup>1</sup>
Cadmium	0.7 - 0.7	1/15	1.1	1.1	0.4	1.28	No	Background <sup>1</sup>
Calcium	N/A	15/15	321	3920	1022.9	810	No	Essential Nutrient <sup>2</sup>
Chromium	N/A	15/15	6.67	55.4	19.6	33	Yes	
Cobalt	1.42 - 1.42	14/15	3.83	14.8	7.5	4.7	Yes	
Copper	N/A	15/15	4.49	38.6	16.8	13.5	Yes	
Iron	N/A	15/15	3540	26000	15577.3	18000	Yes	
Lead	N/A	15/15	3.18	54	10.7	48	Yes	Toxicity Value <sup>3</sup>
Magnesium	N/A	15/15	1070	8220	3587.3	5500	No	Essential Nutrient <sup>2</sup>
Manganese	N/A	15/15	62.8	890	384.3	380	Yes	
Nickel	N/A	15/15	5.3	50.2	29.09	14.6	Yes	
Potassium	N/A	15/15	234	2940	875.7	2400	No	Essential Nutrient <sup>2</sup>
Sodium	N/A	15/15	311	452	403.1	234	No	Essential Nutrient <sup>2</sup>
Vanadium	N/A	15/15	5.14	31.4	11.4	32.3	No	Background <sup>1</sup>
Zinc	N/A	15/15	10.1	70.4	33.9	43.9	Yes	
PAL SEMIVOLATILE ORGANICS								
bis(2-Ethylhexyl)phthalate	0.62 - 3	2/15	0.76	8.1	1.0	NDB	No	Blank <sup>4</sup>
Di-n-butylphthalate	0.061 - 0.3	3/15	0.12	1.3	0.1	NDB	No	Blank <sup>4</sup>
PAL VOLATILE ORGANICS								
Acetone	0.017 - 0.017	1/15	0.062	0.062	0.01	NDB	No	Blank <sup>4</sup>
Trichlorofluoromethane	0.0059 - 0.0059	9/15	0.0057	0.018	0.008	NDB	No	Blank <sup>4</sup>
OTHER								
Total Petroleum Hydrocarbons	21.1 - 28.8	9/15	34.5	566	116.4	NDB	Yes	Toxicity Value <sup>3</sup>





**TABLE 9-3**  
**SUMMARY OF POTENTIAL PATHWAYS FOR HUMAN HEALTH RISK ASSESSMENT**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

POTENTIALLY EXPOSED POPULATION	EXPOSURE ROUTE, MEDIUM, AND POINT	EVALUATED?	REASON FOR SELECTION OR EXCLUSION
<b><u>CURRENT AND FUTURE LAND USE</u></b>			
Utility/Maintenance Worker	Incidental ingestion of subsurface soil	Yes	Performing repairs to utility lines or USTs may expose future workers to contaminated subsurface soil through ingestion route
	Dermal contact with subsurface soil	No	Dermal absorption values not available for CPCs
	Inhalation of particulates from subsurface soil	No	Considered to be insignificant for excavation scenario
	Inhalation of VOCs from subsurface soil	Yes	Performing repairs to utility lines or USTs may expose future workers to VOCs in subsurface soil through inhalation route
	Incidental ingestion and dermal contact with groundwater	No	Workers will be wearing protective clothing which will mitigate impact of these routes
	Inhalation of VOCs from groundwater	Yes	VOCs from shallow groundwater may collect in excavation
Construction Worker	Incidental ingestion of subsurface soil	Yes	Excavation may expose future workers to contaminated subsurface soil through ingestion route
	Dermal contact with subsurface soil	No	Dermal absorption values not available for CPCs
	Inhalation of particulates from subsurface soil	Yes	Greater likelihood that dust will be generated; thus greater likelihood of exposure
	Inhalation of VOCs from subsurface soil	Yes	Excavation may expose future workers to VOCs in subsurface soil through inhalation route
	Incidental ingestion and dermal contact with groundwater	No	Workers will be wearing protective clothing which will mitigate impact of these routes
	Inhalation of VOCs from groundwater	Yes	VOCs from shallow groundwater may collect in excavation
Base Worker	Inhalation of VOCs migrating into basement from groundwater	No	No basements on site
<b><u>FUTURE LAND USE</u></b>			
Commercial/Industrial Worker	Ingestion of drinking water	Yes	Future use of site may be commercial/industrial facility
	Inhalation of VOCs migrating into basement from groundwater	No	Route will be qualitatively evaluated by comparing groundwater concentrations to MADEP MCP GW-2 standards

Notes:  
VOC - Volatile Organic Compound  
UST - Underground Storage Tank  
CPC - Chemical of Potential Concern





**TABLE 9-4**  
**EXPOSURE PARAMETERS**  
**AOC 43J - HISTORIC GAS STATION J**

**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

PARAMETER	CURRENT AND FUTURE		UNITS	SOURCE <sup>1</sup>
	UTILITY/MAINTENANCE WORKER	CONSTRUCTION WORKER		
Soil Ingestion Rate	480	480	mg/day	USEPA, 1991a
Fraction Ingested From Site	100%	100%		Assumption
Relative Absorption Factor	100%	100%		Assumption
Inhalation Rate <sup>2</sup>	4.8	4.8	m <sup>3</sup> /hour	USEPA, 1989a
Exposure Time	8	8	hours/day	Assumption
Exposure Frequency <sup>3</sup>	10	90	days/year	Assumption
Exposure Duration	5	1	years	Assumption
Body Weight	70	70	kg	USEPA, 1991a
Averaging Time				
Cancer	70	70	years	USEPA, 1989b
Noncancer <sup>4</sup>	5	0.25	years	Assumption
Particulate Emission Factor	Not Applicable	4.63+09	m <sup>3</sup> /kg	USEPA, 1991b
Soil-to-Air Volatilization Factor	See Table 9-5	See Table 9-5	m <sup>3</sup> /kg	USEPA, 1991b
Volatiles in Air from Groundwater	Not Applicable	See Table 9-6	mg/m <sup>3</sup>	See Table 9-6

PARAMETER	FUTURE		UNITS	SOURCE <sup>1</sup>
	COMMERCIAL/INDUSTRIAL WORKER			
Drinking Water Ingestion Rate	1		liters/day	USEPA, 1991a
Body Weight	70		kg	USEPA, 1991a
Exposure Frequency	250		days/year	USEPA, 1991a
Exposure Duration	25		years	USEPA, 1991a
Averaging Time				
Cancer	70		years	USEPA, 1991a
Noncancer <sup>4</sup>	25		years	USEPA, 1991a
Relative Absorption Factor	100%			Assumption

**Notes:**

<sup>1</sup> - Exposure variables with source listed as "assumption" are site specific; the remainder are default values.

<sup>2</sup> - Inhalation rate based on the heavy activity rate listed in the Exposure Factors Handbook (USEPA, 1989d)

<sup>3</sup> - 5 days per week for 2 weeks for utility/maintenance worker; 5 days per week for 18 weeks for the construction worker

<sup>4</sup> - The AT for noncarcinogenic effects is equal to the exposure duration; for durations less than one year it is equal to the exposure frequency.

mg - milligrams  
m<sup>3</sup> - cubic meters  
kg - kilograms



TABLE 9-5  
SOIL CONTAMINANT RELEASE ANALYSIS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

CALCULATION OF SOIL-TO-AIR VOLATILIZATION FACTOR (VF)

$$VF = \frac{(LS \times V \times DH)}{A} \times \frac{(3.14 \times AD \times T_{ex})}{(2 \times D_a \times P_a \times K_{aw} \times CF)}$$

Where:

$$AD = \frac{D_a \times P_a}{P_a + (P_a)(1-P_a)/K_{aw}}$$

$$D_a = D_s \times P_{a,33}/P_a$$

$$K_{aw} = \frac{H \times 41}{K_d}$$

$$P_a = P_t - (O \times B)$$

$$P_t = 1 - (B/P_s)$$

$$K_d = K_{ow} \times OC$$

and where:

VF =	volatilization factor (m <sup>3</sup> /kg)
LS =	length of side of contaminated area (m)
V =	wind speed in mixing zone (m/s)
DH =	diffusion height (m)
A =	area of contamination (cm <sup>2</sup> )
D <sub>a</sub> =	effective diffusivity (cm <sup>2</sup> /s)
AD =	adjusted diffusivity (cm <sup>2</sup> /s)
P <sub>a</sub> =	air filled soil porosity (unitless)
P <sub>t</sub> =	total soil porosity (unitless)
O =	soil moisture content (cm <sup>3</sup> -water/g-soil)
B =	soil bulk density (g/cm <sup>3</sup> )
K <sub>aw</sub> =	soil/air partition coefficient (g soil/cm <sup>3</sup> air)
P <sub>s</sub> =	true soil density (g/cm <sup>3</sup> )
T =	exposure interval (s)
OC =	organic carbon content of soil (fraction)
D <sub>s</sub> =	diffusivity in air (cm <sup>2</sup> /s)
H =	Henry's law constant (atm-m <sup>3</sup> /mol)
K <sub>d</sub> =	soil-water partition coefficient (cm <sup>3</sup> /g)
K <sub>ow</sub> =	Organic carbon partition coefficient (cm <sup>3</sup> /g)
CF =	conversion factor (kg/g)

PARAMETER	VALUE	UNITS	SOURCE
LS	45	m	USEPA,1991b
V	2.25	m/s	USEPA,1991b
DH	2	m	USEPA,1991b
A	2.03E+07	cm <sup>2</sup>	USEPA,1991b
P <sub>s</sub>	2.65	g/cm <sup>3</sup>	USEPA,1991b
T	7.90E+08	s	USEPA,1991b
OC	0.02	fraction	USEPA,1991b
O	0.1	cm <sup>3</sup> -water/g-soil	USEPA,1991b
B	1.5	g/cm <sup>3</sup>	USEPA,1991b
-CF	0.001	kg/g	USEPA,1991b





TABLE 9-5  
SOIL CONTAMINANT RELEASE ANALYSIS  
AOC 43G - HISTORIC GAS STATION SITE

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

COMPOUND	D <sub>i</sub> (cm <sup>2</sup> /sec)	H (mole-cm/ mol)	K <sub>oc</sub> (ml/g)	K <sub>d</sub> (ml/g)	D <sub>s</sub> (cm <sup>2</sup> /s)	P <sub>s</sub>	P <sub>t</sub>	K <sub>ow</sub> (g solid/ cm <sup>3</sup> soil)	AD (cm <sup>3</sup> /s)	VF (m <sup>3</sup> /kg)
Acetone	1.15E-01 (1)	3.67E-05 (3)	2.2 (1)	4.40E-02	0.0092	0.28	0.43	3.42E-02	4.70E-05	1.90E+04
Trichlorofluoromethane	9.34E-02 (1)	5.83E-02 (2)	159 (6)	3.18E+00	0.0075	0.28	0.43	7.52E-01	7.58E-04	4.29E+03
Toluene	7.83E-02 (2)	6.60E-03 (4)	120 (7)	2.40E+00	0.0063	0.28	0.43	1.13E-01	1.04E-04	1.26E+04
Ethylbenzene	6.67E-02 (2)	8.43E-03 (5)	220 (7)	4.40E+00	0.0054	0.28	0.43	7.86E-02	6.22E-05	1.64E+04
Xylenes*	7.16E-02 (2)	6.90E-03 (5)	238 (1)	4.76E+00	0.0057	0.28	0.43	5.94E-02	5.07E-05	1.83E+04
Chloroform	8.87E-02 (2)	3.80E-03 (4)	44 (6)	8.80E-01	0.0071	0.28	0.43	1.77E-01	1.84E-04	9.43E+03

Sources:

- (1) Lyman et al., 1982
- (2) Shen, 1982
- (3) Rathburn and Tai, 1982
- (4) Mackay and Shiu, 1981
- (5) Mackay et al., 1979
- (6) Mabey et al., 1982
- (7) Hodson and Williams, 1988

\*values for m-xylene used





TABLE 9-6  
GROUNDWATER CONTAMINANT RELEASE ANALYSIS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

EQUATIONS

1.	$M = C_{gw} \times V \times 0.5$	where:  M = mass of contaminant volatilizing from groundwater per 8 hour workday (mg/workday) C <sub>gw</sub> = average concentration in groundwater (mg/m <sup>3</sup> ) (from Table 9-2) V = volume of groundwater (m <sup>3</sup> ) 0.5 = 50% volatilization in 8 hours (unitless)
2.	$AF = Air_{ws} \times A \times ET \times CF$	where:  AF = air flow through the "box" in 8 hours (m <sup>3</sup> /workday) Air <sub>ws</sub> = air speed (m/sec) A = area of the face of the "box" (m <sup>2</sup> ) ET = time of exposure (hours/day) CF = conversion factor (3600 sec/hr)
3.	$CV_w = M / AF$	where:  CV <sub>w</sub> = Exposure Point Concentration (EPC) in air (mg/m <sup>3</sup> )

VALUES USED

Parameter	Value	Source
V	300 m <sup>3</sup>	Assumption
Air <sub>ws</sub>	3 m/sec	Assumption
A	20 m <sup>2</sup>	Assumption
ET	8 hours	Assumption

CALCULATIONS

Compound	C <sub>gw</sub> (mg/m <sup>3</sup> ) *	AF (m <sup>3</sup> /workday)	M (mg/workday)	CV <sub>w</sub> (mg/m <sup>3</sup> )
<u>Source Area</u>				
Benzene	97.5	1.73E+06	1.46E+04	8.45E-03
Ethylbenzene	1295.0	1.73E+06	1.94E+05	1.12E-01
Toluene	1540.5	1.73E+06	2.31E+05	1.34E-01
Xylenes	2571.6	1.73E+06	3.86E+05	2.23E-01
Carbon Tetrachloride	23.1	1.73E+06	3.47E+03	2.01E-03
Chloroform	57.7	1.73E+06	8.66E+03	5.00E-03
<u>Downgradient Area</u>				
Benzene	2.76	1.73E+06	4.14E+02	2.39E-04
Ethylbenzene	5.55	1.73E+06	8.33E+02	4.81E-04
Toluene	5.61	1.73E+06	8.42E+02	4.86E-04
Xylenes	11.66	1.73E+06	1.75E+03	1.01E-03
Carbon Tetrachloride	0.67	1.73E+06	9.99E+01	5.77E-05
Chloroform	0.91	1.73E+06	1.36E+02	7.86E-05

\*ug/L = mg/m<sup>3</sup>



TABLE 9-7  
ORAL DOSE/RESPONSE INFORMATION FOR CARCINOGENIC EFFECTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIATION INVESTIGATION REPORT  
FORT DEVENS, MA

Compound	Weight of Evidence	Oral Slope Factor (mg/kg/day) <sup>-1</sup>	Test Species	Study Type	Tumor Type	Source
1,2-Dichlorobenzene	D		Mouse	Oral - gavage	Liver tumors	IRIS
1,4-Dichlorobenzene	B2	2.4E-02				HEAST
2,4-Dimethylphenol	ND					IRIS
2-Methylnaphthalene	ND					IRIS
2-Methylphenol	C	ND				IRIS
4-Methylphenol	C	ND				IRIS
Aluminum	Not Listed					
Antimony	ND					
Arsenic	A	1.75E+00 *R	Human	DW	Skin tumors	IRIS
Barium	ND					IRIS
Benzene	A	2.9E-02	Human	Occupational	Leukemia	IRIS
Carbon Tetrachloride	B2	1.3E-01	Several	Oral-gavage	Liver tumors	IRIS
Chloroform	B2	6.1E-03	Flat	DW	Kidney tumors	IRIS
Chromium VI	A	NA				IRIS
Cobalt	ND					IRIS
Copper	D					IRIS
Ethylbenzene	D					IRIS
Iron	Not Listed					
Lead	B2					IRIS
Manganese	D	ND				IRIS
Naphthalene	D					IRIS
Nickel	ND					IRIS
Phenanthrene	D					IRIS
Pyrene	D					IRIS
Toluene	D					IRIS
Xylenes (total)	D					IRIS
Zinc	D					IRIS

NA - Not Applicable  
ND - Not Determined  
R - Under review on IRIS  
DW - Drinking water  
mg - milligram  
kg - kilogram  
IRIS - Integrated Risk Information System

Shaded line indicates CPC evaluated as a carcinogen  
\* - calculated from unit risk of 5E-5 ug/L

SOURCES:

USEPA IRIS as of 5/95

Weight of Evidence:

- A - Human carcinogen
- B - Probable human carcinogen (B1 - limited evidence of cancer in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)
- C - Possible human carcinogen
- D - Not classifiable as to human carcinogenicity
- E - Evidence of lack of carcinogenicity to humans





TABLE 9-8  
INHALATION DOSE/RESPONSE INFORMATION FOR CARCINOGENIC EFFECTS  
AOC 43J - HISTORIC GAS STATION J  
  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

Compound	Weight of Evidence	Inhalation Slope Factor* (mg/kg/day) <sup>-1</sup>	Unit Risk (μg/m <sup>3</sup> ) <sup>-1</sup>	Test Species	Study Type	Tumor Type	Source
1,2-Dichlorobenzene	D						IRIS
1,4-Dichlorobenzene	C	ND	ND				IRIS
2,4-Dimethylphenol	ND						IRIS
2-Methylphenol	C	ND	ND				IRIS
4-Methylphenol	C	ND	ND				IRIS
2-Methylnaphthalene	ND						IRIS
Antimony	ND						IRIS
Arsenic	A	5.0E+01	4.3E-03	Human	Occupational	Respiratory tract	IRIS
Benzene	A	2.9E-02	8.3E-06	Human	Occupational	Leukemia	IRIS
Barium	ND		ND				IRIS
Carbon Tetrachloride	B2	5.3E-02	1.5E-05	Several	Oral-gavage	Liver tumors	IRIS
Chloroform	B2	8.1E-02	2.3E-05	Mouse	Oral-gavage	Liver tumors	IRIS
Chromium VI	A	4.1E+01	1.2E-02	Human	Occupational	Lung tumors	IRIS
Cobalt	ND						IRIS
Copper	D						IRIS
Ethylbenzene	D						IRIS
Iron	Not Listed						IRIS
Lead	B2		ND				IRIS
Manganese	D						IRIS
Naphthalene	D						IRIS
Nickel	ND						IRIS
Phenanthrene	D						IRIS
Pyrene	D						IRIS
Toluene	D						IRIS
Xylenes (total)	D						IRIS
Zinc	D						IRIS

ND - Not Determined  
W - Withdrawn from IRIS  
mg - milligram  
kg - kilogram  
μg - microgram  
m<sup>3</sup> - cubic meter

\* - Source of slope factor is HEAST, 1994 unless otherwise noted.  
Shaded line indicates CFC evaluated as a carcinogen  
  
Sources:  
USEPA IRIS as of 5/95  
IRIS - Integrated Risk Information System  
HEAST - Health Effects Assessment Summary Tables  
  
Weight of Evidence:  
A - Human carcinogen  
B - Probable human carcinogen (B1 - limited evidence in humans;  
B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack  
of evidence in humans)  
C - Possible human carcinogen  
D - Not classifiable as to human carcinogenicity  
E - Evidence of lack of carcinogenicity to humans





TABLE 9-9  
ORAL DOSE/RESPONSE INFORMATION FOR NONCARCINOGENIC EFFECTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

COMPOUND	CHRONIC		SUBCHRONIC		STUDY TYPE	CONFIDENCE LEVEL	CRITICAL EFFECT	TEST ANIMAL	UNCERTAINTY FACTOR	SOURCE
	ORAL RfD (mg/kg-day)	ORAL RfD <sup>1</sup> (mg/kg-day)	ORAL RfD <sup>1</sup> (mg/kg-day)	STUDY TYPE						
1,2-Dichlorobenzene	9E-02	ND	9E-02 #	Oral-diet	Low	No adverse effects observed	Rat	1,000 H.A.D	IRIS	
1,4-Dichlorobenzene	2E-02	ND	2E-01	Oral-gavage	Low	Clinical signs and hematological changes	Mouse	3,000 H.A.D	HEAST	
2,4-Dimethylphenol	ND	ND	ND*	Oral-gavage	Medium	Decreased body weight, neurotoxicity	Rat	1,000 H.A.S	IRIS	
2-Methylnaphthalene	5E-02	5E-03	5E-01	Oral-gavage	Medium	Maternal death, respiratory distress; CNS hypoactivity	Rabbit	1,000	HEAST	
4-Methylphenol (p-Cresol)	1E+00 R	1E+00 R	1E+00 #	Oral-gavage	Medium	Reduced lifespan, altered blood chemistries	Rat	1,000 H.A.L	IRIS	
Aluminum	4E-04	4E-04	4E-04	Oral-DW	Medium	Keratinosis and hyperpigmentation	Human	3 H	IRIS	
Antimony	3E-04 P	3E-04	3E-04	Oral-DW	Medium	Increased blood pressure	Human	3 H	IRIS	
Arsenic	7E-02	7E-02	7E-02	Oral-DW	High	Significant proteinuria	Human	10 H	IRIS	
Barium	3E-04 P	3E-04	3E-04	Oral-DW	Medium	Liver lesions	Rat	1,000 H.A.S	IRIS	
Benzene	5E-04	5E-04	5E-04	Oral-DW	Medium	Fatty cyst formation in liver	Dog	1,000 H.A.S	IRIS	
Cadmium (water)	7E-04	7E-04	7E-04 #	Oral-DW	Low	No effects reported	Rat	500 H.A.S	IRIS	
Carbon Tetrachloride	1E-02	1E-02	1E-02	Oral	Low	Gastrointestinal irritation	Human		HEAST	
Chloroform	5E-03	5E-03	5E-03	Oral	Low	Liver and kidney toxicity	Rat	1,000 H.A.S	IRIS	
Chromium VI	1.8E-01	1.8E-01	1.8E-01 #	Oral	Low					
Cobalt (adult)	3.7E-02	3.7E-02	3.7E-02	Oral	Low					
Copper	1E-01	1E-01	1E-01 #	Oral	Low					
Ethylbenzene	3E-01	3E-01	3E-01 #	Oral-diet	Low					
Iron	ND	ND	ND	Oral-diet	Medium					
Lead	1.4E-01	1.4E-01	1.4E-01	Oral-diet	Medium					
Manganese (food)	5E-03	5E-03	5E-03	Oral-diet	Medium					
Manganese (water)	4E-02 WH	4E-02	4E-02	Oral-diet	Medium					
Naphthalene	2E-02	2E-02	2E-02	Oral-diet	Medium					
Nickel	ND	ND	ND*	Oral-gavage	Low					
Phenanthrene	3E-02	3E-02	3E-02	Oral-gavage	Low					
Pyrene	2E-01	2E-01	2E-01	Oral-gavage	Medium					
Toluene	7E-03 P	7E-03	7E-03	Oral-DW	Medium					
Vanadium	2E+00	2E+00	2E+00 #	Oral-gavage	Medium					
Xylenes (total)	3E-01	3E-01	3E-01	Oral-diet	Medium					
Zinc	ND	ND	ND	Oral-diet	Medium					

ND - No data available

mg - milligram

kg - kilogram

DW - Drinking Water

WH - Water withdrawn from HEAST

P - RfD pending in IRIS

R - as RfD under review by IRIS

IRIS - Integrated Risk Information System

HEAST - Health Effects Assessment Summary Tables

USEPA - United States Environmental Protection Agency

ECOA - Environmental Criteria and Assessment Office

NOAEL - No Observed Adverse Effect Level

LOAEL - Lowest Observed Adverse Effect Level

NOEL - No Observed Effect Level

<sup>1</sup> Source for all subchronic RfDs is HEAST, 1994

\* RfD for naphthalene used as a surrogate

~ ~ Calculated from drinking water standard of 1.3 mg/L

# Subchronic RfD not available; chronic RfD used as surrogate

SOURCES:

USEPA IRIS as of 5/95

ECOA, 1994a,b,c,d,e

USEPA HEAST, 1994 (including July and November updates)

Uncertainty factors:

H - variation in human sensitivity

A - animal to human extrapolation

S - extrapolation from subchronic to chronic NOAEL

L - extrapolation from LOAEL to NOAEL

N - NOEL not attained

D - Lack of supporting data

Additional uncertainty factors or modifying factors (MF)

of 1 to 10 may be added to account for other

uncertainty factors such as inadequacies in the database or

severity of effect.





TABLE 9-10  
INHALATION DOSE/RESPONSE INFORMATION FOR NONCARCINOGENIC EFFECTS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

SUBCHRONIC <sup>1</sup> INHALATION		STUDY TYPE	CONFIDENCE LEVEL	CRITICAL EFFECT	TEST ANIMAL	UNCERTAINTY FACTOR	SOURCE
COMPOUND	RFC (mg/m <sup>3</sup> )						
1,2-Dichlorobenzene	2E+00	Inhalation		Decreased weight gain	Rat	1,000	HEAST <sup>2</sup>
1,4-Dichlorobenzene	2.5E+00	Inhalation		Increased liver weight in male parent	Rat	30	IRIS
2,4-Dimethylphenol	ND						IRIS
2-Methylnaphthalene	Not Listed						IRIS
2-Methylphenol	ND						IRIS
4-Methylphenol	ND						IRIS
Aluminum	Not Listed						IRIS
Antimony	ND						IRIS
Arsenic	ND						IRIS
Benzene	ND						IRIS
Barium	1E-04	Inhalation	Low	Fetotoxicity	Rat	1,000 H,A,S	IRIS
Cadmium	ND						IRIS
Carbon Tetrachloride	ND						IRIS
Chloroform	ND						IRIS
Chromium VI	ND						IRIS
Cobalt	ND						IRIS
Copper	ND						IRIS
Ethylbenzene	1E+00 +	Inhalation	Low	Developmental toxicity	Rat/Rabbit	300 H,A,D	IRIS
Iron	Not Listed						IRIS
Lead	ND <sup>3</sup>						IRIS
Manganese	5E-05 +	Inhalation	Medium	Impairment of neurobehavioral function	Human	1,000 H,L,D	IRIS
Naphthalene	ND						IRIS
Nickel	ND						IRIS
Phenanthrene	ND						IRIS
Pyrene	ND						IRIS
Toluene	4E-01 +	Inhalation	Medium	Neurological effects	Human	300 H,L,D	IRIS
Xylenes (total)	ND						IRIS
Zinc	ND						IRIS

ND - No data available  
mg - milligram  
m<sup>3</sup> - cubic meter  
IRIS - Integrated Risk Information System  
HEAST - Health Effects Assessment Summary Tables  
NOAEL - No Observed Adverse Effect Level  
LOAEL - Lowest Observed Adverse Effect Level  
NOEL - No Observed Effect Level

1 - Source for all subchronic RFCs is HEA; unless otherwise noted  
2 - HEAST Table 2: Alternate Methods  
3 - There is a National Ambient Air Quality Standard for lead of 1.5 ug/m<sup>3</sup> averaged over three months  
+ - Subchronic value not available; chronic value used

Uncertainty factors:  
H - variation in human sensitivity  
A - animal to human extrapolation  
S - extrapolation from subchronic to chronic NOAEL  
L - extrapolation from LOAEL to NOAEL  
N - NOEL not attained  
D - Lack of supporting data

Additional uncertainty factors or modifying factors (MF) of 1 to 10 may be added to account for other uncertainties such as inadequacies in the database or the severity of the effect.

SOURCES:  
USEPA IRIS as of 5/95  
USEPA HEAST, 1994 (including July and November updates)





TABLE 9-11  
QUANTITATIVE RISK SUMMARY  
AOC 43J - HISTORIC GAS STATION J  
REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

	Total Cancer Risk	MEAN EPC Total Hazard Index	Total Cancer Risk	MAXIMUM EPC Total Hazard Index
<b>CURRENT AND FUTURE USE</b>				
<b>SUBSURFACE SOIL (1 - 15 feet bgs) AT SOURCE AREA</b>				
Incidental Ingestion of Subsurface Soil: Utility/Maintenance Worker	3E-07	0.01	5E-07	0.02
Inhalation of Volatiles from Soil and Groundwater: Utility/Maintenance Worker	<u>8E-07</u>	<u>0.01</u>	<u>8E-07</u>	<u>0.01</u>
<b>TOTAL: UTILITY/MAINTENANCE WORKER</b>	<b>1E-06</b>	<b>0.02</b>	<b>1E-06</b>	<b>0.03</b>
Incidental Ingestion of Subsurface Soil: Construction Worker	6E-07	0.4	8E-07	0.6
Inhalation of Volatiles from Groundwater and Particulates and Volatiles from Soil: Construction Worker	<u>1E-06</u>	<u>0.4</u>	<u>1E-06</u>	<u>0.4</u>
<b>TOTAL: CONSTRUCTION WORKER</b>	<b>2E-06</b>	<b>0.8</b>	<b>2E-06</b>	<b>1</b>
<b>SUBSURFACE SOIL (1 - 15 feet bgs) AT PERIMETER AREA</b>				
Incidental Ingestion of Subsurface Soil: Utility/Maintenance Worker	4E-07	0.02	7E-07	0.04
Inhalation of Volatiles from Soil and Downgradient Groundwater: Utility/ Maintenance Worker	<u>2E-08</u>	<u>0.00005</u>	<u>2E-08</u>	<u>0.00005</u>
<b>TOTAL: UTILITY/MAINTENANCE WORKER</b>	<b>4E-07</b>	<b>0.02</b>	<b>7E-07</b>	<b>0.04</b>
Incidental Ingestion of Subsurface Soil: Construction Worker	7E-07	0.8	1E-06	1
Inhalation of Volatiles from Downgradient Groundwater and Particulates and Volatiles from Soil: Construction Worker	<u>3E-08</u>	<u>0.003</u>	<u>3E-08</u>	<u>0.005</u>
<b>TOTAL: CONSTRUCTION WORKER</b>	<b>7E-07</b>	<b>0.8</b>	<b>1E-06</b>	<b>1</b>
<b>FUTURE USE</b>				
<b>SOURCE AREA GROUNDWATER - UNFILTERED</b>				
Ingestion of Groundwater: Commercial/Industrial Worker	3E-04	25	6E-04	53
<b>TOTAL: COMMERCIAL/INDUSTRIAL WORKER</b>	<b>3E-04</b>	<b>25</b>	<b>6E-04</b>	<b>53</b>
<b>SOURCE AREA GROUNDWATER - FILTERED</b>				
Ingestion of Groundwater: Commercial/Industrial Worker	2E-04	24	5E-04	52
<b>TOTAL: COMMERCIAL/INDUSTRIAL WORKER</b>	<b>2E-04</b>	<b>24</b>	<b>5E-04</b>	<b>52</b>
<b>DOWNGRADIENT GROUNDWATER - UNFILTERED</b>				
Ingestion of Groundwater: Commercial/Industrial Worker	3E-05	2	7E-05	7
<b>TOTAL: COMMERCIAL/INDUSTRIAL WORKER</b>	<b>3E-05</b>	<b>2</b>	<b>7E-05</b>	<b>7</b>
<b>DOWNGRADIENT GROUNDWATER - FILTERED</b>				
Ingestion of Groundwater: Commercial/Industrial Worker	6E-07	2	4E-06	6
<b>TOTAL: COMMERCIAL/INDUSTRIAL WORKER</b>	<b>6E-07</b>	<b>2</b>	<b>4E-06</b>	<b>6</b>

NOTES:  
EPC = Exposure Point Concentration





TABLE 9-12  
COMPARISON OF VOLATILE CPCs IN GROUNDWATER TO STANDARDS  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

	Detected Concentrations		Mean of all Samples	MADEP MCP Method 1 GW-2 Standard	Maximum Concentration Exceeds Standard?	Notes
	Minimum	Maximum				
SOURCE AREA GROUNDWATER <sup>a</sup> (mg/L)						
Benzene	0.0015	0.3	0.10	2	No	(1)
Ethylbenzene	0.14	3	1.3	30	No	(1)
Toluene	0.0053	7	1.5	6	Yes	(1)
Xylenes	0.008	8	2.6	6	Yes	(1)
Carbon Tetrachloride	0.02	0.1	0.02	0.02	Yes	(1)
DOWNGRAIDENT GROUNDWATER <sup>b</sup> (mg/L)						
Benzene	0.00056	0.02	0.003	2	No	(1)
Ethylbenzene	0.00092	0.042	0.006	30	No	(1)
Toluene	0.00073	0.042	0.006	6	No	(1)
Xylenes	0.0018	0.089	0.01	6	No	(1)
Carbon Tetrachloride	0.0033	0.0033	0.0007	0.02	No	(1)
Chloroform	0.00086	0.0052	0.0009	0.4	No	(1)

NOTES:

<sup>a</sup> Based on samples XJM-94-05X, XJM-93-02X, -03X, 2446-02 to -04

<sup>b</sup> Based on samples XJM-94-07X to -10X

(1) Average concentration is less than standard

mg - milligram

L - liter

MADEP - Massachusetts Department of Environmental Protection

MCP - Massachusetts Contingency Plan

CPC - Chemical of Potential Concern



TABLE 9-13  
COMPARISON OF SOURCE AREA GROUNDWATER CONCENTRATIONS TO  
STANDARDS AND GUIDELINES  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

COMPOUNDS	FREQUENCY OF DETECTION	MAXIMUM DETECTED CONCENTRATION (mg/L)	ARITHMETIC AVERAGE CONCENTRATION (mg/L)	FEDERAL MCLs (mg/L)	MASS. MCLs (mg/L)	MASS. GUIDELINES (mg/L)
<b>UNFILTERED SAMPLES</b>						
<b>Volatile Organics</b>						
Benzene	10/12	0.3	0.1	0.005	0.005	ND
Ethylbenzene	10/12	3	1.3	0.7	0.7	ND
Toluene	12/12	7	1.5	1	1	ND
Xylenes	12/12	8	2.6	10	10	ND
Carbon tetrachloride	3/12	0.1	0.02	0.005	0.005	ND
<b>Semivolatile Organics</b>						
1,2-Dichlorobenzene	3/12	0.014	0.003	0.6	0.6	ND
1,4-Dichlorobenzene	1/12	0.0036	0.001	0.075	0.005	ND
2,4-Dimethylphenol	1/12	0.0088	0.003	ND	ND	ND
2-Methylnaphthalene	9/12	0.1	0.03	ND	ND	ND
2-Methylphenol	2/12	0.0053	0.002	ND	ND	ND
4-Methylphenol	4/12	0.011	0.002	ND	ND	ND
Naphthalene	12/12	0.3	0.1	ND	ND	ND
<b>Inorganics</b>						
Aluminum	11/12	21	5.7	0.05 - 0.2 (3)	0.05 - 0.2 (3)	ND
Arsenic	12/12	0.0878	0.04	0.05	0.05	ND
Barium	12/12	0.119	0.1	2	2	ND
Cadmium	1/12	0.00579	0.002	0.005	0.005	ND
Calcium	12/12	87.7	54.3	ND	ND	ND
Chromium	7/12	0.0351	0.01	0.1	0.1	ND
Cobalt	1/12	0.0306	0.01	ND	ND	ND
Copper	5/12	0.0325	0.01	1.3 (4)	1.3	ND
Iron	12/12	49.7	21	0.3 (3)	0.3 (3)	ND
Lead	12/12	0.0267	0.008	0.015 (4)	0.015	ND
Magnesium	12/12	18.2	12.6	ND	ND	ND
Manganese	12/12	18.2	9.6	0.05 (3)	0.05 (3)	ND
Nickel	2/12	0.0626	0.02	0.1	0.1	ND
Potassium	12/12	74.6	3.7	ND	ND	ND
Sodium	12/12	68.9	47.2	20 (5)	ND	20
Vanadium	3/12	0.0276	0.009	ND	ND	ND
Zinc	6/12	0.62	0.1	2 (2)/5 (3)	5 (3)	ND





TABLE 9-13  
COMPARISON OF SOURCE AREA GROUNDWATER CONCENTRATIONS TO  
STANDARDS AND GUIDELINES  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

COMPOUNDS	FREQUENCY OF DETECTION	MAXIMUM DETECTED CONCENTRATION (mg/L)	ARITHMETIC AVERAGE CONCENTRATION (mg/L)	FEDERAL MCLs (mg/L)	MASS. MCLs (mg/L)	MASS. GUIDELINES (mg/L)
<b>FILTERED SAMPLES</b>						
Antimony	1/12	0.00375	0.002	0.006	0.006	ND
Arsenic	12/12	0.0726	0.03	0.05	0.05	ND
Barium	12/12	0.0298	0.02	2	2	ND
Calcium	12/12	61	53.8	ND	ND	ND
Copper	1/12	0.0133	0.004	1.3 (4)	1.3	ND
Iron	12/12	30	10.5	0.3 (3)	0.3 (3)	ND
Lead	5/12	0.00618	0.002	0.015 (4)	0.015	ND
Magnesium	12/12	15.6	11	ND	ND	ND
Manganese	12/12	18.4	9.6	0.05 (3)	0.05 (3)	ND
Potassium	12/12	3.38	2.5	ND	ND	ND
Sodium	12/12	67.7	48	20 (5)	ND	20

Shaded line denotes either average or maximum (or both) concentration(s) of analyte exceeds at least one of the drinking water standards or guidelines

NA = Not applicable ND = No value available

MCL = Maximum Contaminant Level

(1) For all trihalomethanes

(2) USEPA lifetime health advisory

(3) Secondary MCL

(4) USEPA action level

(5) USEPA drinking water equivalency level (DWEL) - A lifetime exposure concentration protective of adverse, non-cancer health effects that assumes all exposure is from a drinking water source

References:

USEPA, 1995. "Drinking Water Regulations and Health Advisories." Office of Water, Washington, D.C.; May, 1995.

MADEP, 1994. "Drinking Water Standards & Guidelines for Chemicals in Massachusetts Drinking Waters." Office of Research and Standards; Boston, M





**TABLE 9-14**  
**COMPARISON OF DOWNGRADENT GROUNDWATER CONCENTRATIONS TO**  
**STANDARDS AND GUIDELINES**  
**AOC 43J - HISTORIC GAS STATION SITE**  
**REMEDIAL INVESTIGATION REPORT**  
**FORT DEVENS, MA**

COMPOUNDS	FREQUENCY OF DETECTION	MAXIMUM DETECTED CONCENTRATION (mg/L)	ARITHMETIC AVERAGE CONCENTRATION (mg/L)	FEDERAL MCLs (mg/L)	MASS. MCLs (mg/L)	MASS. GUIDELINES (mg/L)
<b>UNFILTERED SAMPLES</b>						
<b>Volatile Organics</b>						
Benzene	2/9	0.02	0.003	0.005	0.005	ND
Ethylbenzene	2/8	0.042	0.006	0.7	0.7	ND
Toluene	3/8	0.042	0.006	1	1	ND
Xylenes	2/8	0.089	0.01	10	10	ND
Carbon tetrachloride	1/8	0.0033	0.0007	0.005	0.005	ND
<b>Semivolatile Organics</b>						
Naphthalene	1/8	0.0065	0.001	ND	ND	ND
<b>Inorganics</b>						
Aluminum	8/8	13.9	2.5	0.05 - 0.2 (3)	0.05 - 0.2 (3)	ND
Arsenic	5/8	0.0114	0.004	0.05	0.05	ND
Barium	8/8	0.0991	0.03	2	2	ND
Calcium	8/8	48.3	32.2	ND	ND	ND
Chromium	2/8	0.0392	0.008	0.1	0.1	ND
Copper	1/8	0.015	0.005	1.3 (4)	1.3	ND
Iron	8/8	22.5	4.7	0.3 (3)	0.3 (3)	ND
Lead	4/8	0.0144	0.004	0.015 (4)	0.015	ND
Magnesium	8/8	23.7	11.5	ND	ND	ND
Manganese	8/8	2.33	0.8	0.05 (3)	0.05 (3)	ND
Nickel	1/8	0.0559	0.02	0.1	0.1	ND
Potassium	8/8	6.74	3.4	ND	ND	ND
Sodium	8/8	19.2	11.5	20 (5)	ND	20
Vanadium	1/8	0.016	0.007	ND	ND	ND
Zinc	1/8	0.0506	0.02	2 (2)/5 (3)	5 (3)	ND
<b>FILTERED SAMPLES</b>						
Antimony	1/8	0.00491	0.002	0.006	0.006	ND
Arsenic	1/8	0.00373	0.002	0.05	0.05	ND
Barium	6/8	0.0219	0.01	2	2	ND
Calcium	8/8	60.5	32.7	ND	ND	ND
Iron	1/8	0.0483	0.02	0.3 (3)	0.3 (3)	ND
Magnesium	8/8	22.6	11.2	ND	ND	ND
Manganese	8/8	2.75	0.8	0.05 (3)	0.05 (3)	ND
Potassium	6/8	5.74	2.3	ND	ND	ND
Sodium	8/8	17.9	11	20 (5)	ND	20

Shaded line denotes either average or maximum (or both) concentration(s) of analyte exceeds at least one of the drinking water standards or guidelines

NA = Not applicable ND = No value available

MCL = Maximum Contaminant Level

(1) For all trihalomethanes

(2) USEPA lifetime health advisory

(3) Secondary MCL

(4) USEPA action level

(5) USEPA drinking water equivalency level (DWEL) - A lifetime exposure concentration protective of adverse, non-cancer health effects that assumes all exposure is from a drinking water source

References:

USEPA, 1995. "Drinking Water Regulations and Health Advisories." Office of Water, Washington, D.C.; May, 1995.

MADEP, 1994. "Drinking Water Standards & Guidelines for Chemicals in Massachusetts Drinking Waters." Office of Research and Standards; Boston, MA; Autumn, 1994.





TABLE 9-15  
POTENTIAL SOURCES OF UNCERTAINTY  
AOC 43J - HISTORIC GAS STATION J

REMEDIAL INVESTIGATION REPORT  
FORT DEVENS, MA

UNCERTAINTY	EFFECT	JUSTIFICATION
Likelihood of exposure pathways	Overestimate	Future exposures may not actually occur
Degradation of chemicals not considered	Overestimate	Risk estimates are based on recent chemical concentrations. Concentrations will tend to decrease over time as a result of degradation, so future exposures may be to lower concentrations.
Extrapolation of animal toxicity data to humans	Unknown, probably overestimate	Animals and humans differ with respect to absorption, metabolism, distribution, and excretion of chemicals. The magnitude and direction of the difference will vary with each chemical. Animal studies typically involve high-dose exposures, whereas humans are exposed to low doses in the environment.
Use of linearized, multistage model to derive cancer slope factors	Overestimate	Model assumes a non-threshold, linear-at-low-dose relationship for carcinogens. Many compounds induce cancer by non-genotoxic mechanisms. Model results in a 95% upper confidence limit of the cancer risk. The true risk is unlikely to be higher and may be as low as zero.
Summation of effects (cancer risks and hazard indices) from multiple substances	Unknown	The assumption that effects are additive ignores potential synergistic and/or antagonistic effects. Assumes similarity in mechanism of action, which is not the case for many substances. Compounds may induce tumors or other toxic effects in different organs or systems.
Uses of uncertainty factors in the derivation of reference doses.	Unknown	Ten-fold uncertainty factors are incorporated to account for various sources of uncertainty. Although some data seem to support the ten-fold factor, its selection is somewhat arbitrary.
Application of the RfD for naphthalene to all PAHs without RfDs and assumption that their effects are additive.	Overestimate	Naphthalene is one of the most toxic representatives of noncarcinogenic PAHs and will bias estimates of risk high.
Exclusion of analytes from quantitative evaluation because no toxicity information is available.	Underestimate	The exclusion of analytes without toxicity values from quantitative evaluation may bias estimates of risk low.
A single detection of an inorganic analyte above background concentrations results in including this analyte as a CPC.	Overestimate	The selection of an inorganic as a CPC due to one concentration above background can bias risk and may not be representative of site conditions. The average may be more representative of site conditions.
The use of an oral absorption factor of 1	Overestimate	The assumption of 100% gastrointestinal absorption of chemicals on soil is conservative.
Dermal exposure to soil not evaluated because of lack of dermal absorption factors.	Underestimate	Dermal contact with soils may produce some incremental risk and the inability to quantify the risk may bias the total risk estimate low.
Data set too small to allow calculation of the 95% UCL to evaluate central tendency risk. Arithmetic mean used instead.	Unknown, probably underestimate	The 95% UCL is intended to provide reasonable confidence that the true site average is not underestimated. The arithmetic mean may underestimate the true site average.





## 10.0 CONCLUSIONS AND RECOMMENDATIONS

RI activities were conducted by ABB-ES personnel at AOC 43J to evaluate the nature and distribution of the groundwater and soil contamination detected during previous investigations. A summary of the RI findings is presented in the following subsections.

### 10.1 CONCLUSIONS

The following conclusions are based on interpretation of data collected from each of the previous investigation (SI, SSI and RI) completed at AOC 43J.

- Wastes released at AOC 43J included waste oil and gasoline from former USTs.
- The geologic setting at AOC 43J includes a soil fill layer underlain by glacial till above a metasilstone and phyllitic bedrock.
- The hydrogeologic condition at AOC 43J can be defined as an unconfined aquifer. The water table was encountered below the bedrock surface in the northwest corner of the AOC, but predominantly the water table was encountered in the overburden soil across the remainder of the AOC. The groundwater appears to flow primarily to the east-northeast.
- Based on the distribution of the soil contamination, it appears that contents from both of the former USTs have added equal amounts of contaminants to the soil at AOC 43J. Soil contamination was detected below and east of the former UST locations. Soil contaminants consisted of VOCs (i.e., BTEX), SVOCs (i.e., naphthalene and phenanthrene), and TPHC. The soil contamination east of the former UST locations, appears to be located in a 5-foot smear zone created from waste oil and gasoline contaminants floating on the rising and falling water table. The zone extends from 7 to 11 feet bgs in an area approximately 180

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feet by 150 feet. Soil contamination does not appear to have reached the bedrock surface below this zone of contamination.

- Potential health risks associated with exposure to subsurface soil at the source area and the perimeter area of AOC 43J were evaluated. The primary CPCs identified in soil were ethylbenzene, toluene, xylene, noncarcinogenic PAHs, and inorganic compounds. The exposure scenarios evaluated were for a utility/maintenance worker and a construction worker. Estimated carcinogenic risks did not exceed the USEPA risk range or MADEP MCP risk level. Similarly, potential noncarcinogenic risks did not exceed the USEPA and MADEP MCP target level.
- The groundwater in the source area at AOC 43J is contaminated with several VOCs (BTEX, 1,2-DCE, 1,2-DCA, carbon tetrachloride) and SVOC (1,2-dichlorobenzene; 1,4-dichlorobenzene; 2,4-dimethylnaphthalene; methylphenol (2-cresol and 4-cresol); naphthalene; and phenanthrene) above appropriate standards and/or guidelines. Several other organic contaminants (VOCs, SVOCs, and TPHC) were also detected in the groundwater samples collected from AOC 43J, however, these compounds were detected at concentrations that did not exceed their federal MCLs or MADEP MCP concentrations.

The groundwater results also indicated that several inorganics were present in unfiltered groundwater samples above the established Fort Devens background and drinking water standards. However, a comparison of these results to filtered groundwater samples and TSS concentrations indicates that the unfiltered concentrations are a result of suspended solids and not dissolved site-related contaminants.

Based upon the results of the RI groundwater sampling, the distribution of groundwater contamination appears to still be within the existing fenced area around the 10th Special Forces motor pool, except for the northwest portion of the AOC (i.e., XJM-94-04X and XJM-94-09X).

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- Risks associated with exposure to unfiltered and filtered groundwater were evaluated for groundwater representing the source area and for groundwater identified as downgradient. The receptor evaluated was a future commercial/industrial worker. Estimated carcinogenic risks for unfiltered groundwater exceeded the USEPA target risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  for exposure to both mean and maximum concentrations of CPCs in source area groundwater ( $3 \times 10^{-4}$  and  $6 \times 10^{-4}$ , respectively). Arsenic was the primary contributor to the excess risk (exceeding  $1 \times 10^{-4}$  risk level). Assuming exposure to maximum concentrations, benzene and carbon tetrachloride produced individual risks above  $1 \times 10^{-5}$ . In unfiltered downgradient groundwater, estimated carcinogenic risks were within the USEPA target risk range. HIs for the source area are 25 and 53 for exposure to mean and maximum concentrations, respectively. Benzene, manganese, iron, and arsenic are the primary contributors for source area groundwater. Estimated noncarcinogenic HIs for downgradient groundwater are 2 and 7 for mean and maximum concentrations, respectively. Manganese and benzene are the primary contributors for downgradient groundwater. Individual HQs for the primary contributors in both source area and downgradient groundwater all exceed the USEPA target level of one.
- Risks were estimated for commercial/industrial worker exposure to filtered groundwater assuming that concentrations of organic CPCs remain the same as in unfiltered groundwater. Estimated carcinogenic risks exceeded the USEPA risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  for exposure to both mean and maximum concentrations of CPCs in source area groundwater ( $2 \times 10^{-4}$  and  $5 \times 10^{-4}$ , respectively). Arsenic and benzene were the primary contributors to the excess risk for mean concentrations; while arsenic, benzene, and carbon tetrachloride were contributors at maximum concentrations. At both mean and maximum concentrations, only arsenic produced individual risks above  $1 \times 10^{-4}$ . In downgradient groundwater, exposure to both mean and maximum concentrations produced risks within the USEPA range ( $1 \times 10^{-5}$  and  $3 \times 10^{-5}$ , respectively). Estimated noncarcinogenic HIs for the source area are 24 and 52 for exposure

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to mean and maximum concentrations, respectively. Benzene and manganese are primary contributors at mean concentrations, while benzene, manganese and arsenic are the primary contributors for maximum concentrations of filtered source area groundwater. HIs for downgradient groundwater are 2 and 6 for mean and maximum concentrations, respectively. Manganese is the only contributor with an HQ exceeding one.

- If the modified cancer slope factor for arsenic was used to estimate excess lifetime cancer risks, then the cancer risks associated with exposure to both average and maximum concentrations of arsenic in unfiltered and filtered groundwater would fall below  $1 \times 10^{-4}$ .
- A comparison of detected concentrations of CPCs in source area and downgradient groundwater to federal and state drinking water standards and guidelines showed several exceedances. In source area groundwater, the following CPCs were detected at concentrations above a federal or state standard or guideline: benzene, ethylbenzene, toluene, carbon tetrachloride, chloroform, naphthalene, arsenic, cadmium, lead, sodium, aluminum, iron, and manganese. In downgradient groundwater, detected concentrations of benzene, chloroform, aluminum, iron, and manganese exceed federal or state drinking water standards or guidelines.

### 10.2 RECOMMENDATIONS

Based on the results and interpretation of the physical and chemical data and taking into account the future use of this AOC which appears to be vehicle storage for Army Reserve Units, ABB-ES recommends the following action for the groundwater:

- Perform an FS to evaluate alternatives to reduce potential commercial/industrial human health risks associated with potential future exposure to groundwater at the source area directly downgradient of the former UST locations.

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- Evaluate alternatives to prevent potential future migration of contaminants to downgradient areas.

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## GLOSSARY OF ACRONYMS AND ABBREVIATIONS

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ABB-ES	ABB Environmental Services, Inc.
AOC	Area of Contamination
ARAR	applicable or relevant and appropriate requirements
ARF	Analysis Request Form
ATEC	ATEC Environmental Consultants
BEHP	bis(2-ethylhexyl)phthalate
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/sec.	centimeters per second
CFR	Code of Federal Regulations
CLP	Contact Laboratory Program
CMR	Code of Massachusetts Regulations
COC	chain-of-command
CPC	chemical of potential concern
CSF	cancer slope factor
°C	degrees Celsius
°F	degrees fahrenheit
1,2-DCE	1,2-dichloroethene
DDT	dichlorodiphenyl trichloroethane
DO	dissolved oxygen
DQO	Data Quality Objective
EA	Environmental Applications, Inc.
ECAO	Environmental Criteria Assessment Office
E&E	Ecology & Environment, Inc.
ELCD	electrolytic conductivity detector
EMO	Environmental Management Office
EPC	exposure point concentration
ETA	Engineering Technologies Associates, Inc.
FID	flame ionization detector
FFA	Federal Facilities Agreement

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## **GLOSSARY OF ACRONYMS AND ABBREVIATIONS**

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GC	gas chromatograph
gpm	gallons per minute
GPR	ground-penetrating radar
GPRI	Geophysics GPR International, Inc.
GZAR	GZA Remediation, Inc.
H	Henry's Law Constant
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Table
HI	hazard index
HQ	hazard quotient
HSA	hollow stem augers
ID	inside diameter
IDW	investigation-derived waste
IR	infrared spectrophotometer
IRDMIS	Installation Restoration Data Management Information System
IRIS	Integrated Risk Information System
K <sub>oc</sub>	organic carbon partition coefficient
LUSTs	leaking underground storage tanks
MAAF	Moore Army Airfield
MADEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MCP	Massachusetts Contingency Plan
MDL	method detection limits
MEP	Master Environmental Plan
mg/kg	milligrams per kilogram
mL	milliliter
mg/L	milligrams per liter
MMCL	Massachusetts Maximum Contaminant Level
mph	miles per hour
MS	mass spectroscopy

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## GLOSSARY OF ACRONYMS AND ABBREVIATIONS

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MS/MSD	matrix spike/matrix spike duplicate
NCP	National Contingency Plan
NDIR	non-dispersed infrared
NPL	National Priorities List
NWR	National Wildlife Refuge
OD	outside diameter
OSHA	Occupational Safety and Health Administration
PAH	polynuclear aromatic hydrocarbon
PAL	Project Analyte List
PARCC	precision, accuracy, representativeness, completeness, and comparability
PC	personal computer
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PID	photoionization detector
ppb	parts per billion
ppm	parts per million
POP	Project Operations Plan
PQL	Practical Quantitation Limit
PRE	preliminary risk evaluation
PRI	Potomoc Research, Inc.
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RAS	Routine Analytical Services
RBC	risk-based concentration
RfD	reference dose
RI	Remedial Investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RPD	relative percent difference

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## GLOSSARY OF ACRONYMS AND ABBREVIATIONS

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SA	Study Area
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SAS	Special Analytical Services
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SI	Site Investigation
SMCL	Secondary Maximum Contaminant Level
SQL	sample quantitation limit
SSI	Supplemental Site Investigation
SVOC	semivolatile organic compound
TBC	to be considered
1,1,2,2-TCA	1,1,2,2-tetrachloroethane
TCE	trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TEX	toluene, ethylbenzene and xylenes
TIC	tentatively identified compounds
TPHC	Total Petroleum Hydrocarbons
TOC	Total Organic Carbon
TSS	total suspended solids
UCL	upper confidence limit
UL	Underwriters Laboratory
USAEC	U.S. Army Environmental Center
USATHAMA	U.S. Army Toxic Hazardous Materials Agency
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per Liter
µg/ml	micrograms per milliliter
UST	underground storage tank

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## **GLOSSARY OF ACRONYMS AND ABBREVIATIONS**

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VC	vinyl chloride
VOC	volatile organic compound
WPA	Works Progress Administration

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